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FIELD APPLICATION OF UH-1 SONIC ANALYZER

By

Meyer B. Salomonsky

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U. S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

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Final Report

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SUMMARY

This report covers work performed during a U. S. Army Aviation Materiel Laboratories (USAAVLABS) in-house program to conduct a field application of the UH-1 series helicopter to evaluate the sonic analyzer and to verify the component-level limits determined by Curtiss-Wright Corporation under a previous Government contract.

The test program consisted of taking 33 runs on 11 UH-1 series helicopters. Real time analyses, along with analyses from magnetic tape recordings, were performed.

The CWEA-4 Sonic Analyzer shows good potential as a successful indicator of power train component anomalies for the UH-1 series helicopters based on the satisfactory performance and operational characteristics exhibited during the field application program.

Test results indicate that the following work must be done before the sonic analyzer can become operational:

1. Take readings with known malfunctions to determine the signature of a discrepant component.

2. Determine to what extent the analysis will be made at the operational level and at the depot level.

3. Make minor modifications on the analyzer.

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LIST OF SYMBOLS AND ABBREVIATIONS

ADGB	Accessory drive gearbox
Assy	Assembly
Brg	Bearing
Cal	Calibrate
cps	Cycles per second
CWEA	Curtiss-Wright Engine Analyzer
C_1	Compressor rotor blade passage frequency
d_1	Bearing inner race diameter, inches
d_2	Bearing outer race diameter, inches
d_B	Bearing rolling element diameter, inches
Eng	Engine
f_1	Bearing frequency caused by irregularity on inner raceway, cps
f_2	Bearing frequency caused by irregularity on outer raceway, cps
f_B	Bearing frequency caused by spin of rolling elements, cps
f_B'	Bearing frequency caused by rough spot on rolling element, cps
$3f_B'$	Third harmonic of f_B' (3 times f_B'), cps
f_R	Fundamental rotational frequency of engine, gear shaft, or bearing shaft, cps
f_T	Bearing frequency caused by rotation of train of rolling elements, cps; or tracking frequency, cps

Gen	Generator
Gov	Governor
Hrs	Hours
Hyd	Hydraulic
I. D.	Inside diameter, inches
Locking Signal	The frequency used for tracking engine rpm variation (within $\pm$ 1%) which must be present on all engines 100% of the time and does not have any other discrete signals within $\pm$ 400 cps. (Any variation in engine rpm above or below the $\pm$ 1% range will alter this limit accordingly.)
m	Number of bearing rolling elements
Max	Maximum
Mic	Microphone
N1	Gas producer rotor speed, rpm
N2	Power turbine rotor speed, rpm
O. D.	Outside diameter, inches
OUPT	Output
Peg	Full scale
Ref	Reference
rpm	Revolutions per minute
rps	Revolutions per second
S/N	Serial number
Tach	Tachometer
TBO	Time between overhauls
TT	Total time

TSO	Time since overhaul
XMSN	Transmission
X2	Twice the fundamental rotational frequency of engine, gear shaft, or bearing shaft, cps

BACKGROUND

The feasibility of diagnostic sonic analysis was demonstrated during a U. S. Army Aviation Materiel Laboratories (USAAVLABS) sponsored program conducted by Curtiss-Wright Corporation. A UH-1 series helicopter sonic analyzer was designed and fabricated, and a limited field application program was conducted on the X-19 power transmission system in conjunction with the X-19 Development, Qualification, and Assurance Test Program.* The objective of this contract was to develop a single analyzer capable of monitoring the complete power train dynamic system of the UH-1 series helicopter.

The analyzer is capable of monitoring the mechanical condition of the rotating elements in the engine, transmission, shafting, and tail rotor gearboxes. The sonic diagnostic analysis of the X-19 transmission was successful in detecting the majority of the system anomalies, including a gear fatigue failure, several bearing failures, and gear tooth scuffing conditions.

As a result of the success of the X-19 sonic analysis program, Curtiss-Wright was awarded a contract to design and fabricate a sonic analyzer with an acoustic plug-in module with UH-1 complete dynamic system capability and to conduct a limited field application and evaluation program. The results of these programs indicated that correlation existed between the CWEA-4 analysis and the mechanical condition of the transmission power train components; however, further investigation was required to establish criteria for detecting abnormal conditions.

At the termination of the Curtiss-Wright programs, this command initiated an in-house program to evaluate the sonic analyzer in a field application.

Tests were conducted at Fort Eustis, Virginia, from January 1968 to May 1968. The test program consisted of taking 33 runs on 11 UH-1 series helicopters. Real time analyses, along with analyses from magnetic tape recordings, were performed.

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*Locklin, R. G., DIAGNOSTIC NOISE STUDY OF POWER TRANSMISSION SYSTEMS, Curtiss-Wright Corporation; USAAVLABS Technical Report 66-55, U. S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, September 1966, AD 642523.

The purposes of the task were to validate the condition-level limits determined by Curtiss-Wright and to determine the capability of the Curtiss-Wright Engine Analyzer (CWEA-4) to analyze UH-1 series helicopter dynamic systems. The specific UH-1 helicopter models, including engine models, for which this analyzer was designed are as follows:

Helicopter Model	Engine Model
UH-1A	T53-L-1A
UH-1B	T53-L-9, -9A, -11
UH-1C	T53-L-9, -9A, -11
UH-1D	T53-L-9, -9A, -11

MECHANICAL DATA AND ANALYSIS*

The mechanical data for the various rotating components were obtained by the contractor prior to the fabrication of the module for the UH-1 series helicopters. These data consisted of power transmission speeds, shaft speeds, number of gear teeth for each gear concerned, dimensions of races and rolling elements of bearings, engine installation, and gearbox locations.

The predicted frequencies of the various rotating components were computed for a flight idle condition by using these data. Sample calculations are described in the appendix of this report. The engine and transmission operating speeds for ground operation of the various UH-1 helicopter models at flight idle conditions were established as designated below:

Helicopter Component	Tachometer Setting**
N1 - Engine Compressor Rotor	60%
N2 - Transmission Input Drive Bevel Gear	4500 rpm

*A detailed description of the above mechanical and acoustic analysis, the module design, and the analyzer fabrication is given in CWEA-4 SONIC ANALYZER WITH UH-1 HELICOPTER CAPABILITY by W. B. Gray and R. G. Locklin, Curtiss-Wright Corporation; USAAVLABS Technical Report 68-28, U. S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, May 1968, AD 674198.

**It should be noted that these are nominal values, and some helicopter models will be required to operate at N1 and N2 speed settings that may differ from the nominal speeds. During the conduct of the in-house program, locks were successfully obtained within the range of 58% - 62% and 4400 rpm - 4600 rpm. (The lock allows the analyzer to track a particular component regardless of engine rpm within the above limits.) As the unit has a $\pm$ 3% tracking capability, these settings were satisfactory.

CWEA-4 SONIC ANALYZER DESCRIPTION

The CWEA-4 Sonic Analyzer (Figure 1) consists of a power supply, the basic CWEA Sonic Analyzer with UH-1 helicopter plug-in module capability, three microphones, a tape programmer, and associated cabling. During the house task covered by this report, a four-channel recorder and a fourth microphone were also used. The purposes of the recorder were to shorten the real time analysis and to use the tape obtained to complete the analysis. The tape can also be used to obtain noise spectrograms for use in a more comprehensive analysis.

The power supply can operate from line voltage (115 volts, 60 or 400 cps) or from an internal bank of thirty-eight 1.25-volt batteries. The present prototype version will operate for 30 minutes on battery power, after which it requires a charging time of approximately 4 hours. The prototype

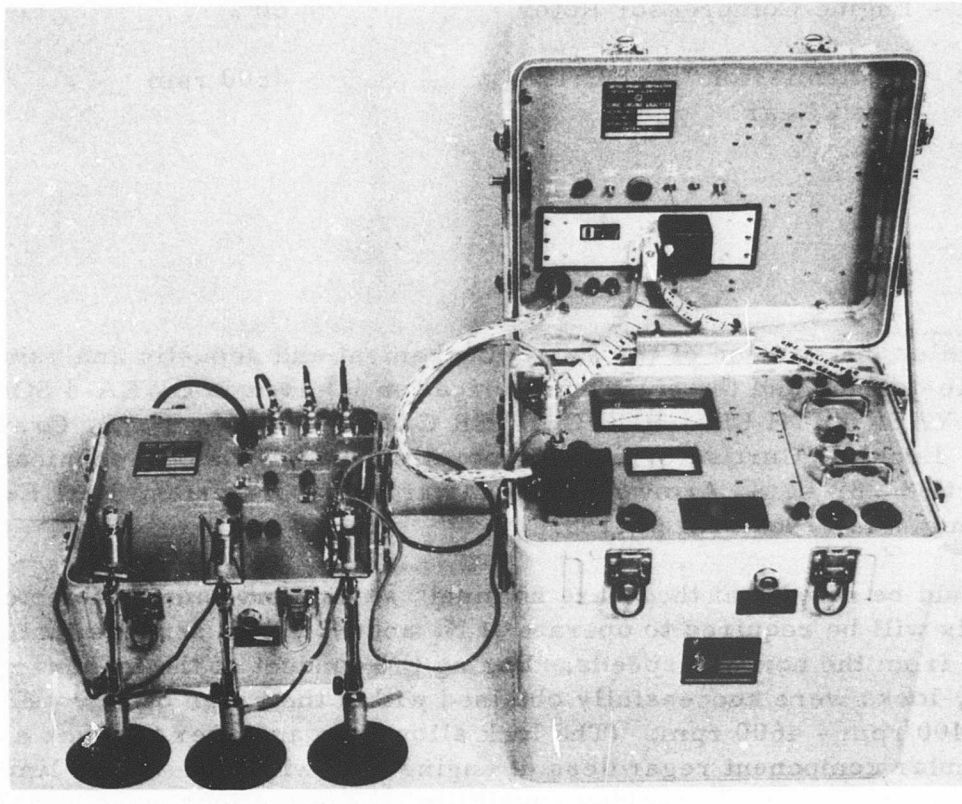


Figure 1. CWEA-4 Sonic Analyzer.

power supply system weighs 51 pounds. A considerable weight reduction is anticipated on production models of the power supply system.

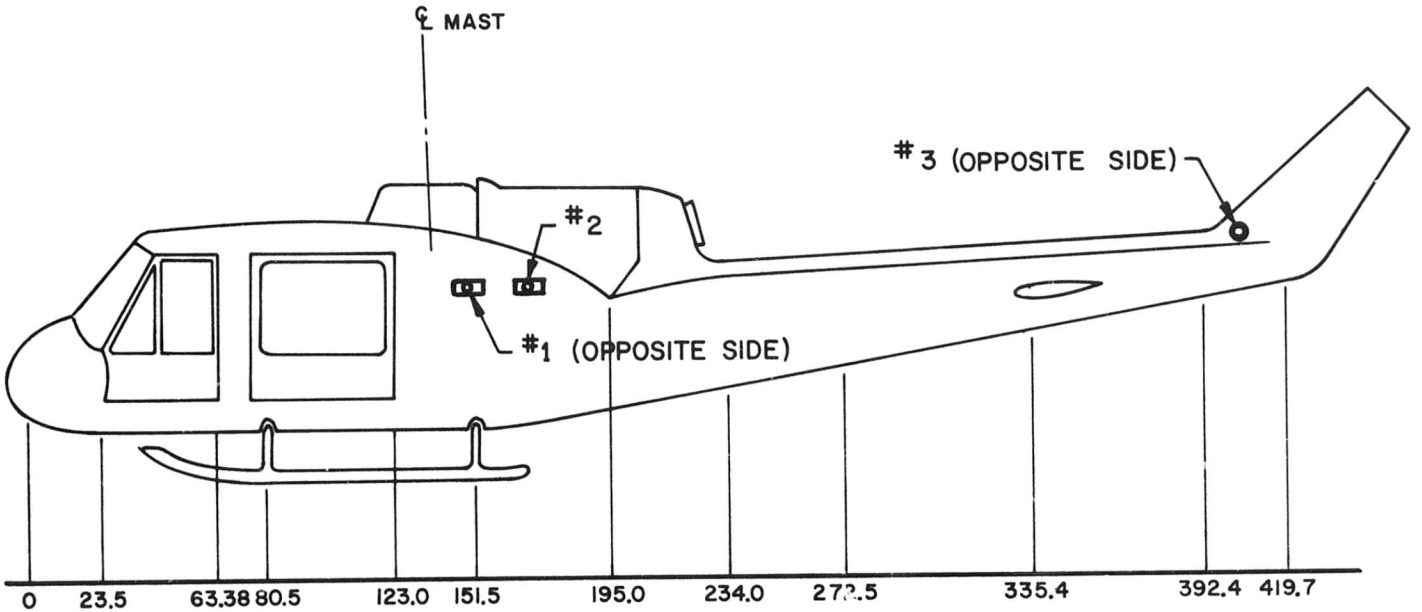
The microphone system consists of three condenser microphones (Figures 2 through 6) located as follows:

Microphone 1	Located approximately 10 inches inside the transmission right inspection door and aimed at the center section of the transmission on the vertical center line for aircraft models UH-1A, UH-1B, and UH-1C. Located approximately 2 inches from the right side of the transmission cover housing (6 inches above top of cabin) directly opposite the transmission vertical center line and aimed at the top of the transmission for aircraft model UH-1D.
Microphone 2	Located approximately 10 inches inside the engine left inspection door and aimed at a point halfway between the engine N1 and N2 accessory drive gearboxes on a vertical line through the parting line of the two gearbox housings.
Microphone 3	Located approximately 2 inches from the right side of the 42-degree gearbox cover housing and aimed at the center of the gearbox.

A three-prong bracket was used to mount microphones 1 and 2 at the respective transmission and engine inspection doors on all model helicopters except the UH-1D (Figure 4). On model UH-1D, a suction cup was used for the microphone 1 installation (Figure 5). A suction cup was also used to mount microphone 3 on all model helicopters (Figure 6).

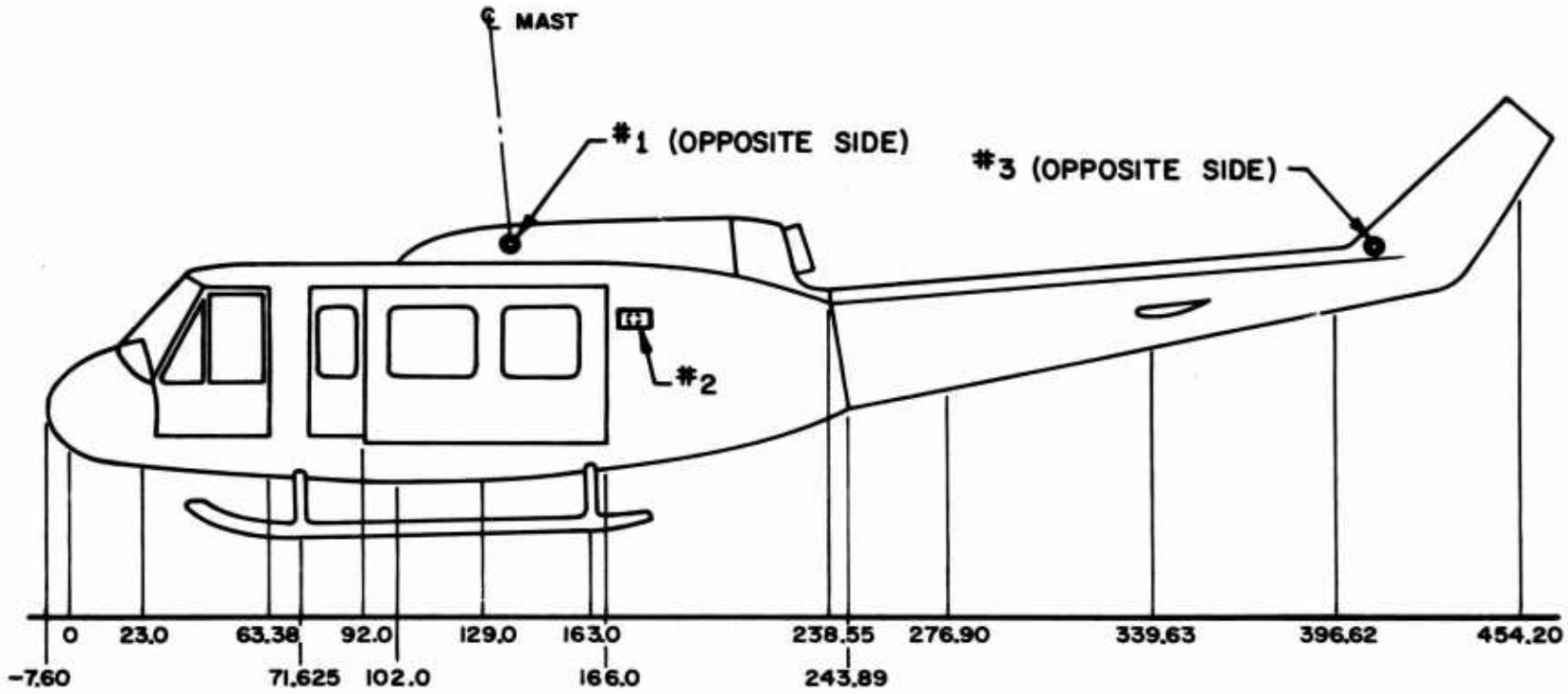
The analyzer unit itself receives inputs from the three microphones, passes the signal through a narrow band-pass filter, and compares the amplitude of the signal with a predetermined amplitude. This normalized signal is then read on the condition-level meter. From this reading, the condition of the component being analyzed can be determined. The primary engine/transmission component limits were established by using the UH-1 helicopter data recorded at Fort Rucker, Alabama, in September 1966.* The analysis of these data resulted in a gain setting required to

*W B. Gray and R. G. Locklin, CWEA-4 SONIC ANALYZER WITH UH-1 HELICOPTER CAPABILITY, Curtiss-Wright Corporation; USAAVLABS Technical Report 68-28, U. S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, May 1968, AD 674198.



Mic	Location
1	Clamped in forward access panel opening on right side of helicopter - extends 10 inches inside - aimed at vertical center line of transmission center section.
2	Clamped in rear access panel opening on left side of helicopter - extends 10 inches inside - aimed midway between N1 and N2 accessory drive gearboxes.
3	Fastened on right side of tail section with suction cup - 3 inches away from skin - aimed at 42-degree gearbox.

Figure 2. Microphone Locations for Main Rotor Transmission and Tail Rotor Gearboxes - Models UH-1A, UH-1B, and UH-1C Helicopters.



Mic	Location
1	Mounted on right side of engine cowl using suction cup - 3 inches away from skin - aimed at mast center line.
2	Clamped in forward access panel opening on left side of helicopter - extends 10 inches inside - aimed midway between N1 and N2 accessory drive gearboxes.
3	Fastened on right side of tail section with suction cup - 3 inches away from skin - aimed at 42-degree gearbox.

Figure 3. Microphone Locations for Main Rotor Transmission and Tail Rotor Gearboxes - Model UH-1D Helicopter.

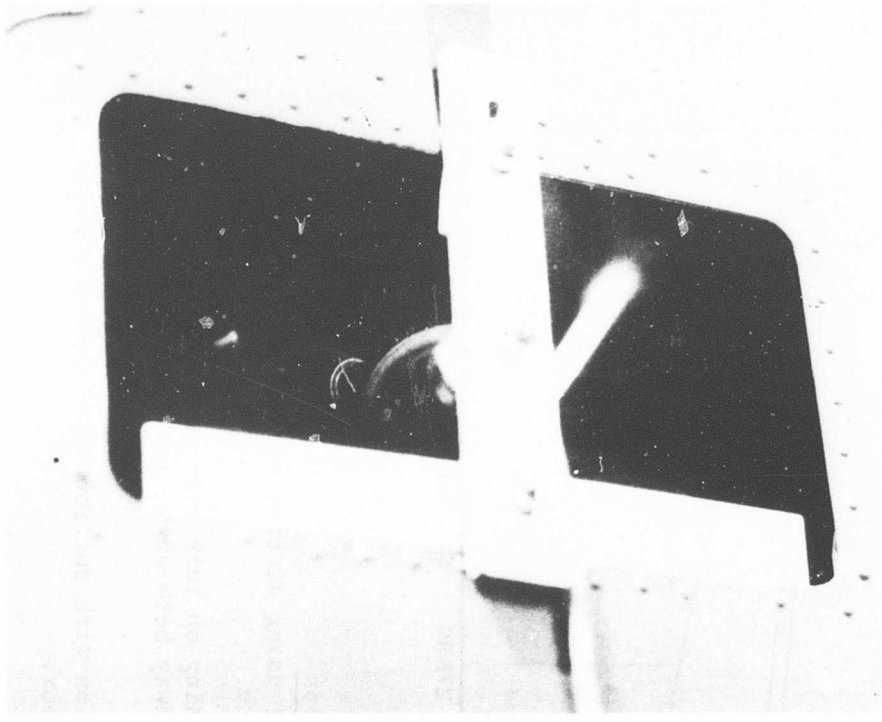


Figure 4. Typical Installation of Microphones 1 and 2 on Models UH-1A, UH-1B, and UH-1C Helicopters.

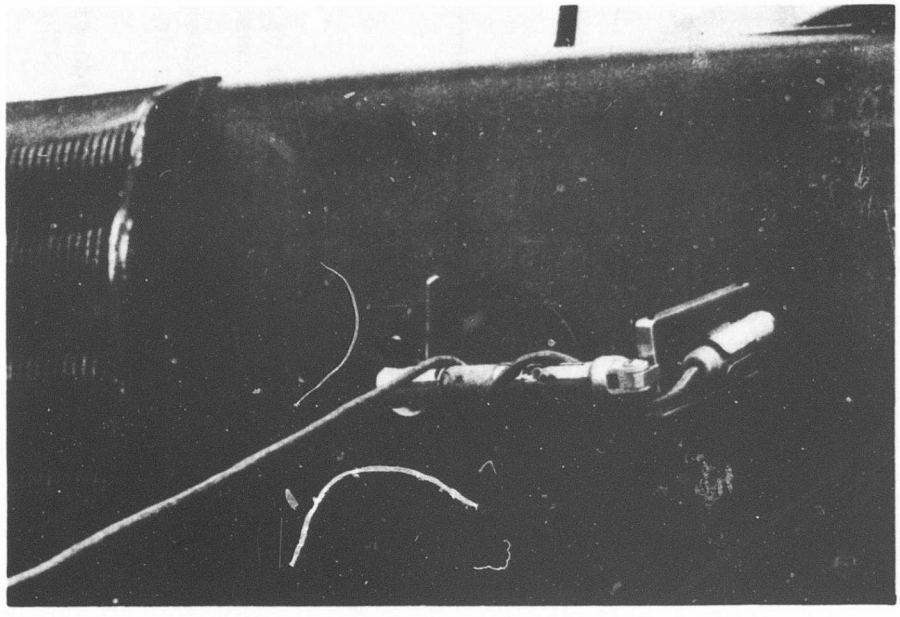


Figure 5. Typical Installation of Microphone 1 on Model UH-1D Helicopter.

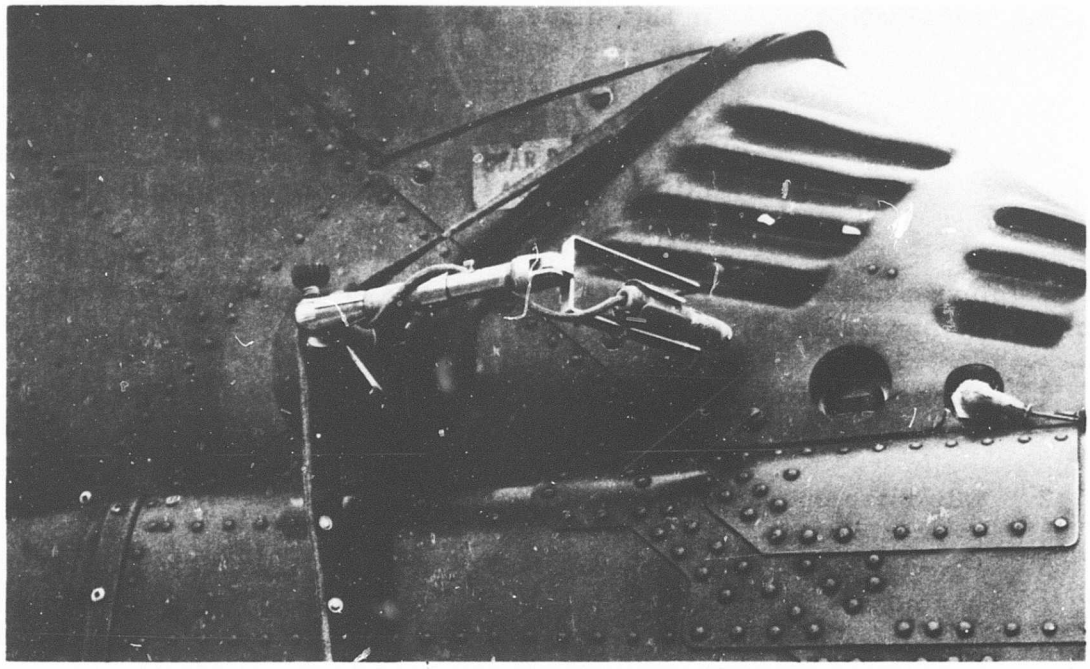


Figure 6. Typical Installation of Microphone 3 on Models UH-1A, UH-1B, UH-1C, and UH-1D Helicopters.

produce a half-scale deflection of the condition-level meter, which reads from 0 to 10. Normally, a reading of 8 or above indicates a reject component. Reject limits for each component are shown in Tables I, II, and III.

The analyzer has the capability of operating in three different modes:

1. Manual — The operator manually sets the test level, the gain I and II switches, the ratio select switch, the microphone select switch, and the lock select switch. The read switch is depressed and the condition level is read. This process has to be repeated for each component.

2. Semiautomatic — In this mode of operation, a program tape is used. The program tape automatically sets all of the above logic, and the operator merely depresses the tape driver switch for each successive reading. The condition level is still read as above. This method was used during the program being reported, although both the manual and the automatic modes were periodically checked.

3. Automatic — In this mode, the movement of the automatic tape is controlled by a clock. A predetermined reference signal is contained in the logic circuitry. If the amplitude of the monitored signal is above that of the reference signal, a magnetic latching relay is energized, stopping the tape and lighting the indicator lamp.

The automatic mode of operation of the analyzer is considered to be superior to the manual mode, in that it will:

1. Virtually eliminate the human error in adjusting settings necessary for monitoring each component.

2. Minimize operator decision of component condition.

3. Provide a more efficient method of monitoring sidebands and harmonics of signals.

The analyzer unit, with the automatic system, weighs 50 pounds.

A detailed description of the analyzer and power supply is contained in the Operation and Maintenance Manual, Model CWEA-3, 4 Sonic Analyzer.

FIELD APPLICATION PROGRAM

DATA ACQUISITION

Thirty-three runs were made on eleven UH-1 series helicopters. The condition-level data from these tests are contained in Tables I, II, and III. Tables I and III contain data for the transmission components, the 42-degree gearbox, and the 90-degree gearbox. Table II contains data for the engine components.

The gear train schematics for the T53 engine and the power train components of the UH-1 helicopter are shown in Figures 7 through 11. The identification code used in these figures is as follows:

1. The number written in parentheses is used for the identification and location of the individual components. This number corresponds to the number in the applicable table and on the program tape.

2. The number printed on the gears indicates the number of gear teeth.

3. The number underlined indicates the component shaft speed in revolutions per second (rps).

RESULTS

YUH-1D Helicopter, Serial No. 60-6032

The results of the inspections performed on the YUH-1D helicopter Serial No. 60-6032, along with the time since overhaul of the various components, are as follows:

Date	1/18/68	2/14/68	5/6/68
Eng TSO (hrs)	381:00	405:58	458:03
Trans TSO (hrs)	1084:00	1108:58	1161:03
90-Degree Gearbox TSO (hrs)	1084:00	1108:58	1161:03
42-Degree Gearbox TSO (hrs)	1084:00	1108:58	1161:03

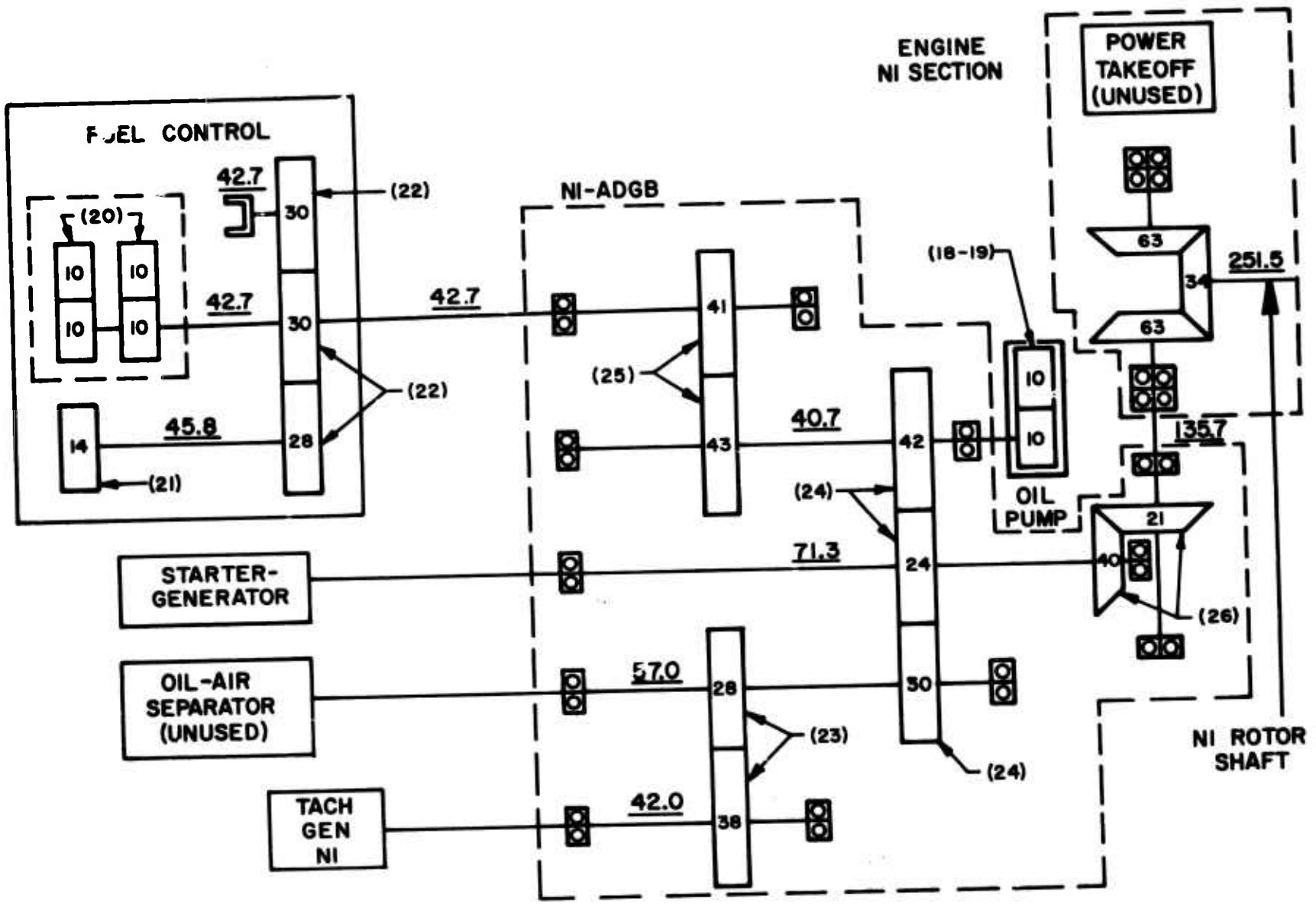


Figure 7. Gear Train Schematic - Models T53-L-9, T53-L-9A, and T53-L-11 Engines - Gas Producer Section (N1).

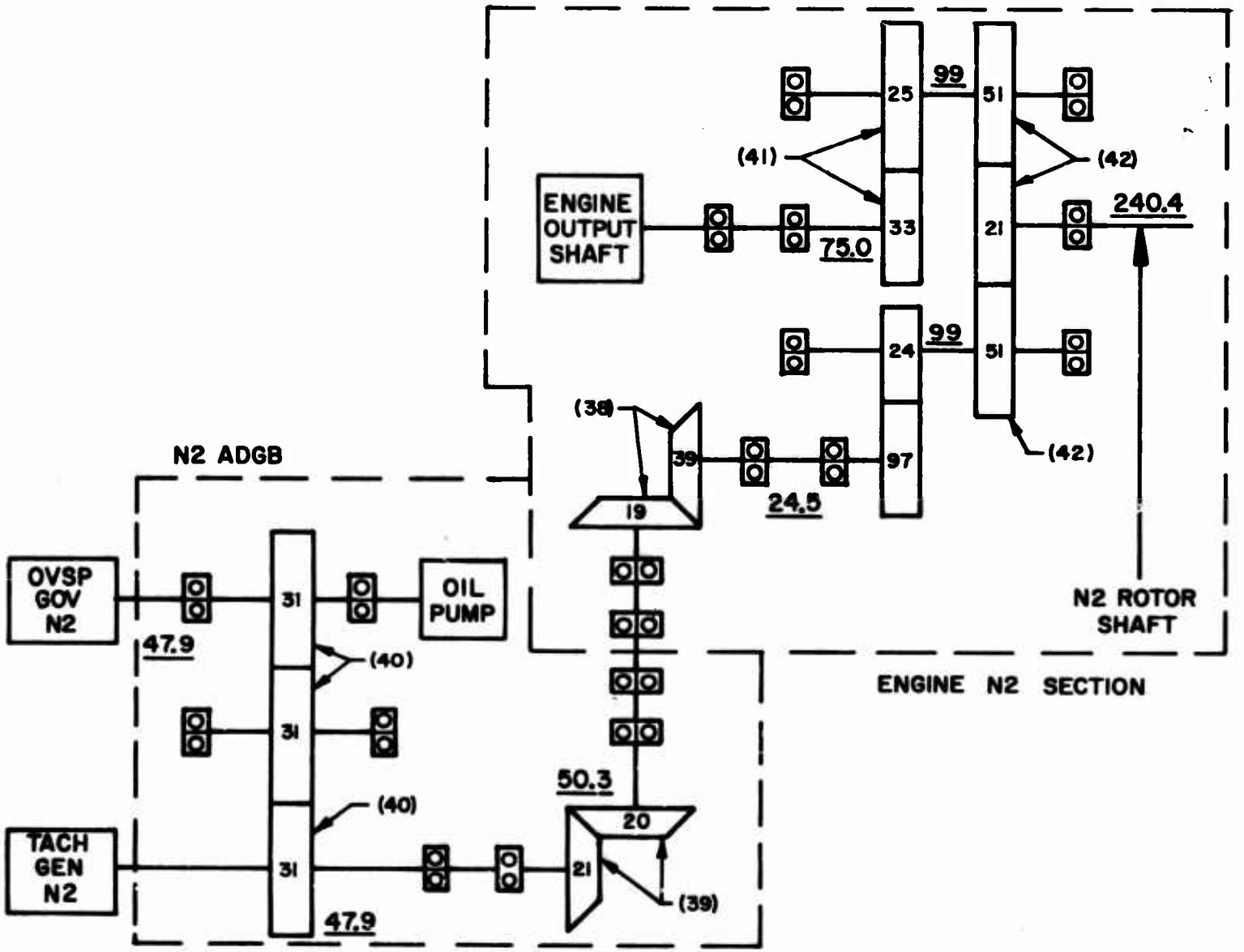


Figure 8. Gear Train Schematic - Models T53-L-9, T53-L-9A, and T53-L-11 Engines - Power Turbine Section (N2).

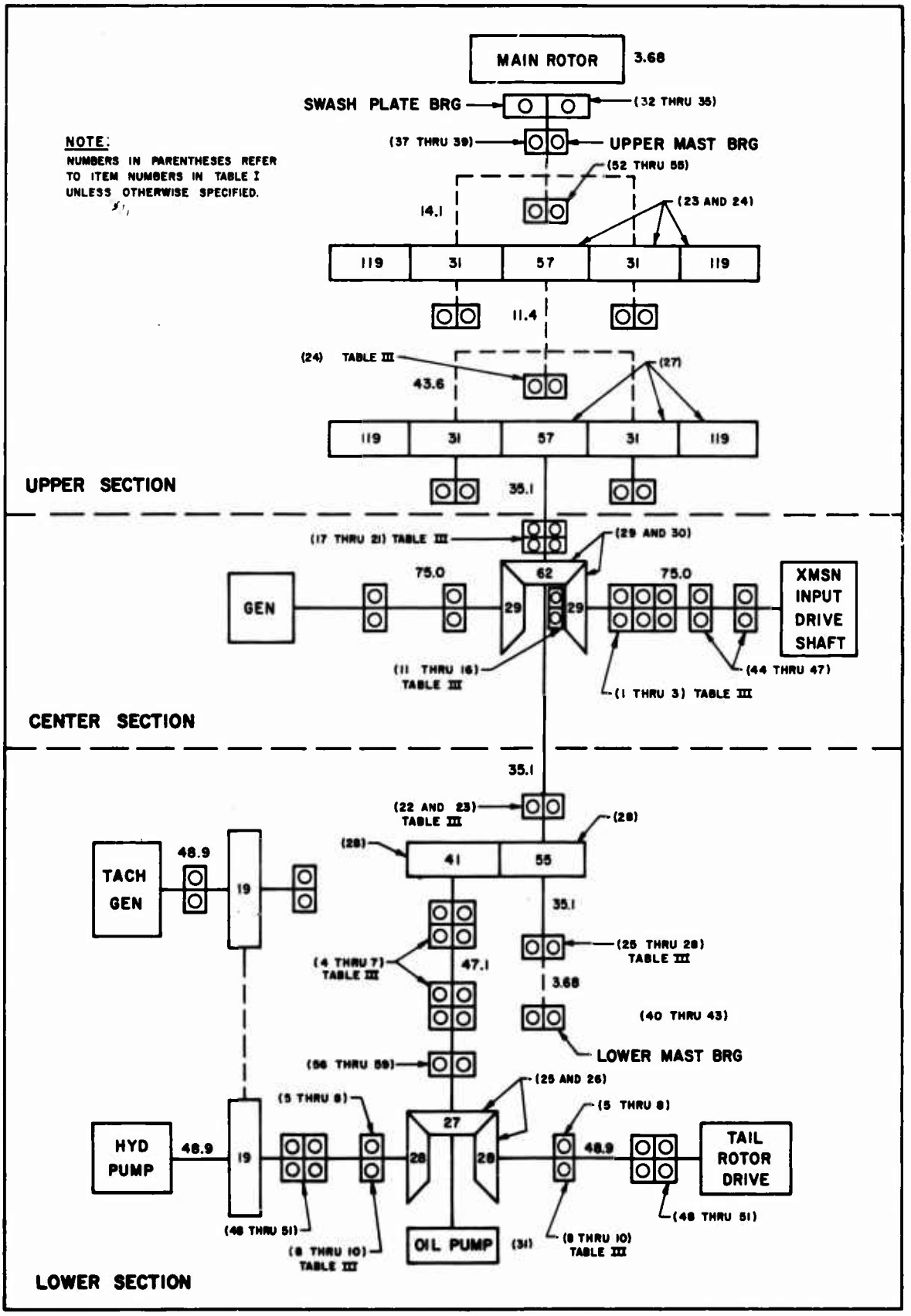


Figure 9. Gear Train Schematic - Model UH-1B Helicopter Main Rotor Transmission.

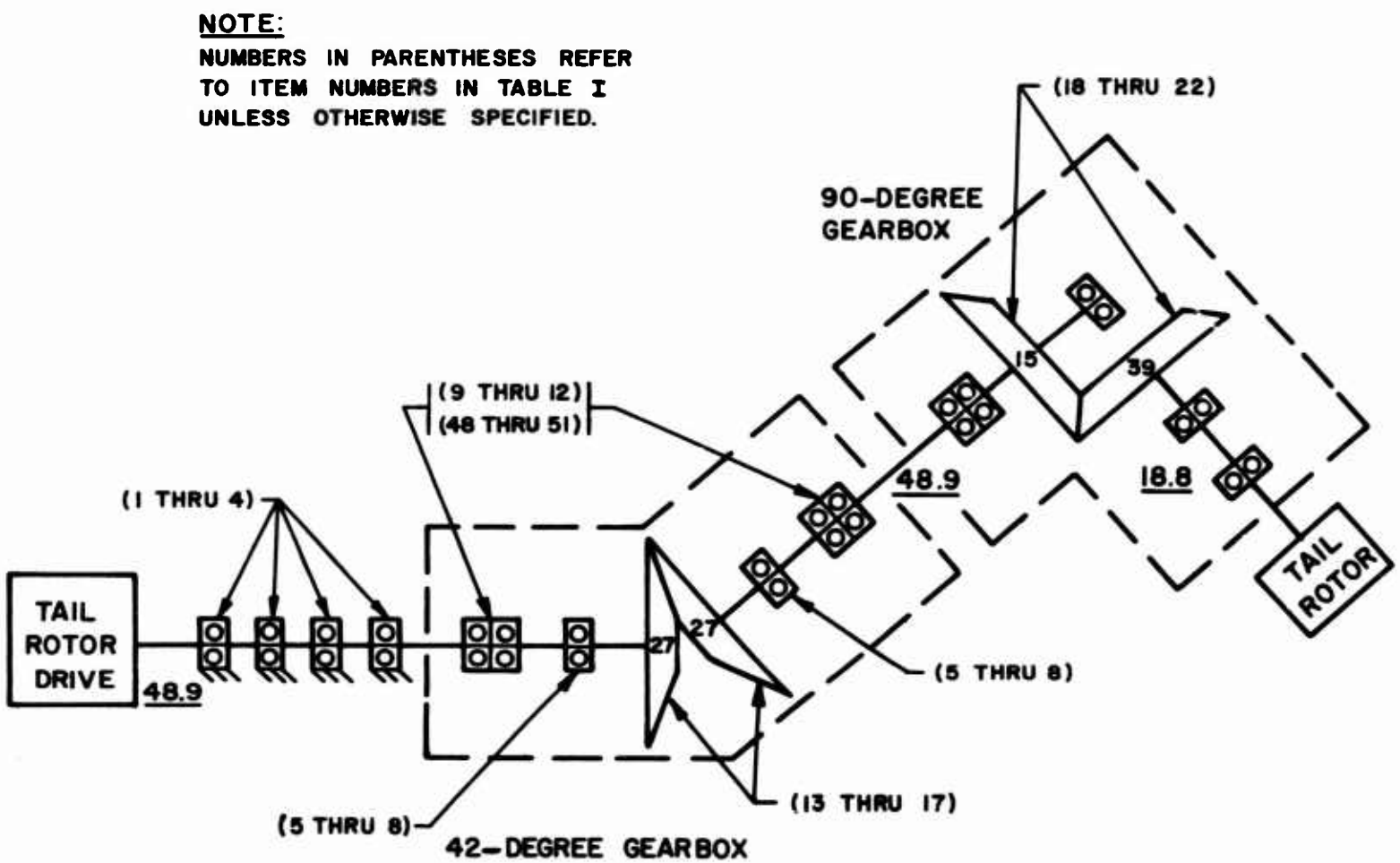


Figure 10. Gear Train Schematic - Models UH-1A, UH-1B, UH-1C, and UH-1D Helicopter Tail Rotor Gearboxes.

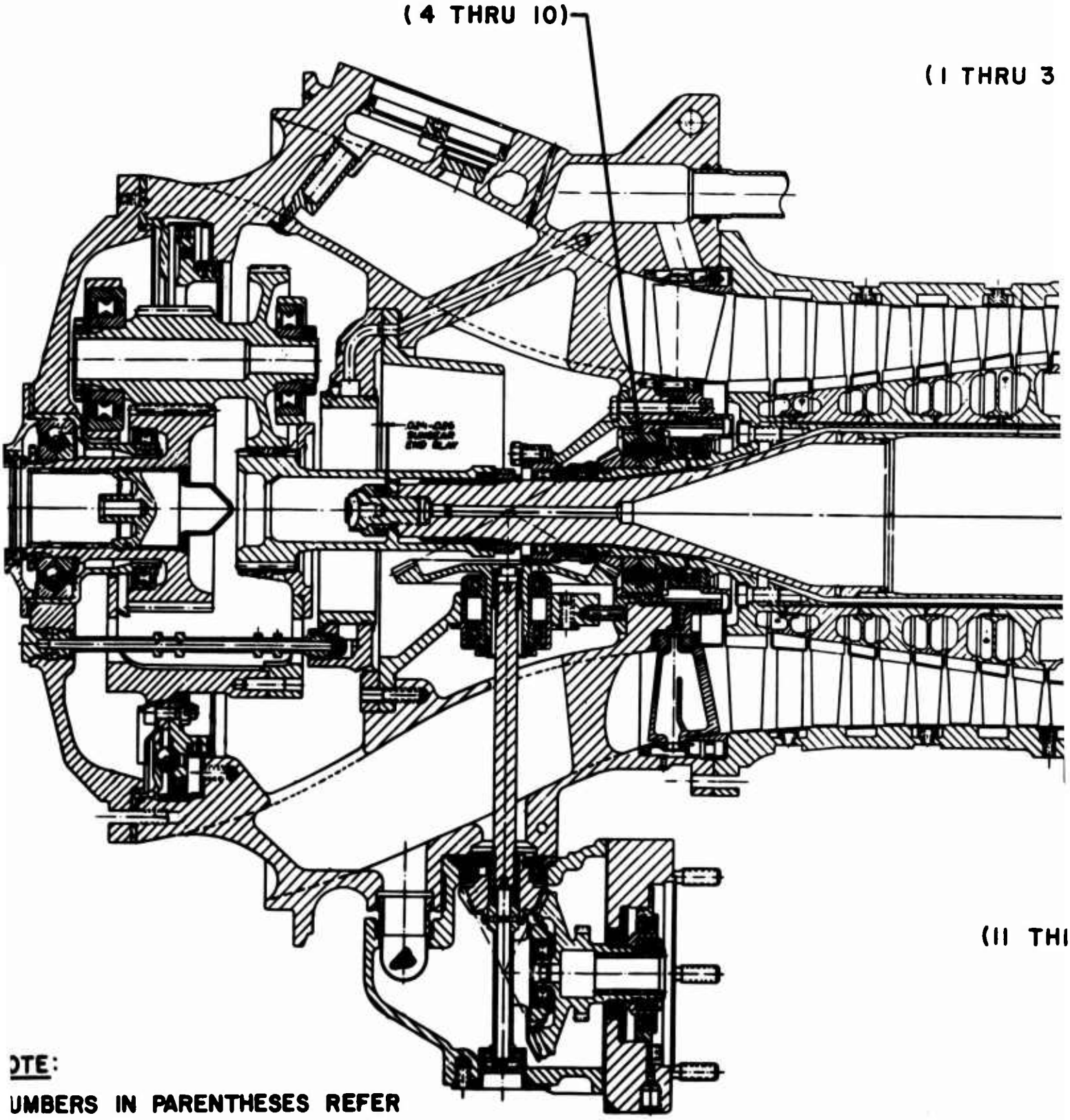
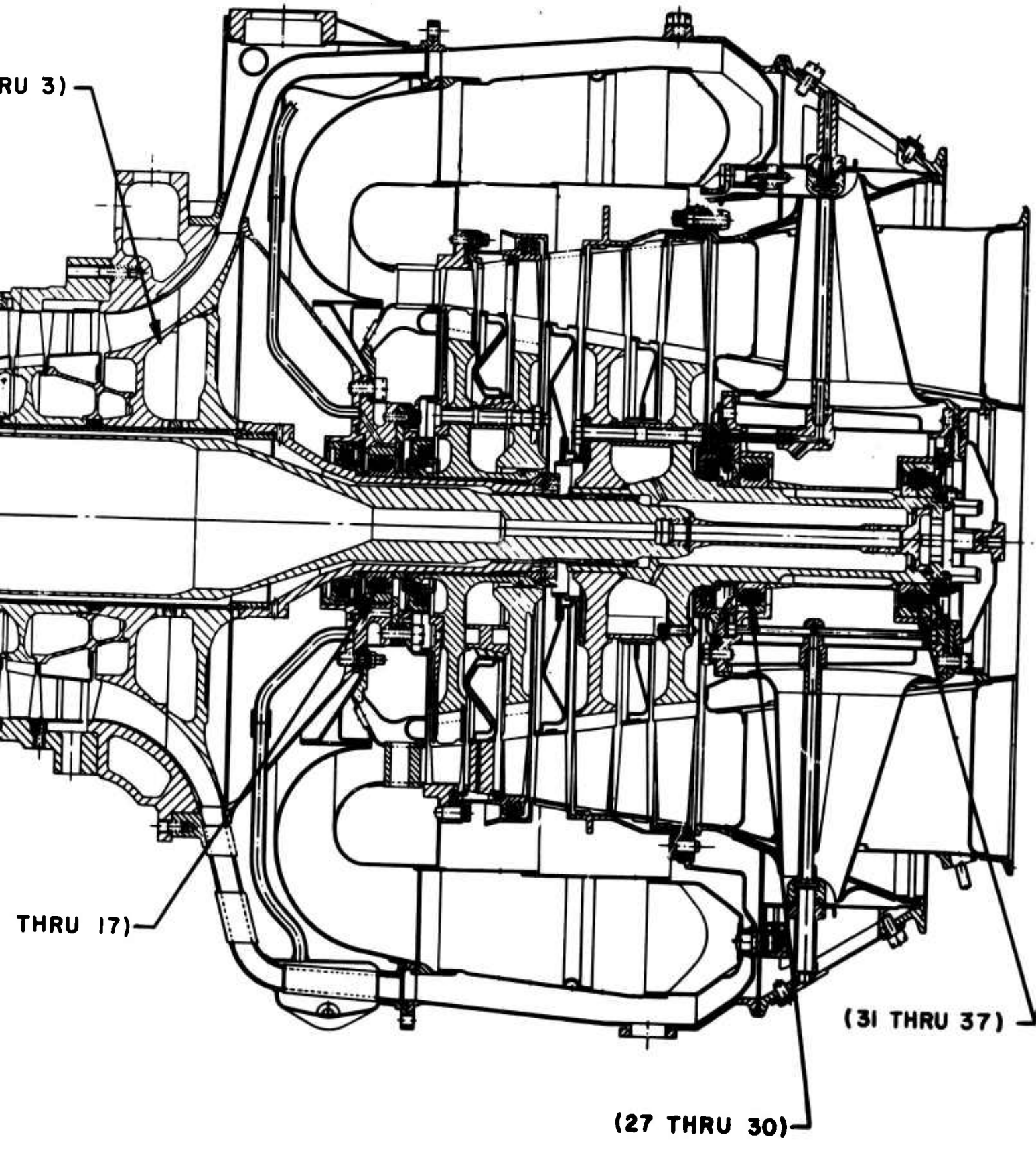


Figure 11. Schematic Diagram of Model T53-L Engines.


RU 3)
THRU 17)
(31 THRU 37)
(27 THRU 30)

During the week of 3 June to 7 June, a hot end inspection was made on this aircraft because of repeated high exhaust gas temperature readings. The inspection revealed a discrepant No. 3 main bearing. A review of the sonic analyzer tape taken on 6 May did not indicate an excessively high level condition for this bearing; however, the readings for this bearing were definitely higher than the readings taken on 14 February. It should be noted that the readings taken on 18 January were approximately the same as those taken on 6 May (see Table II, items 27 through 30). No explanation could be made for the comparatively low reading of 14 February.

On 14 February, a high indication was noted on the inner raceway of both the single-row and the double-row bearings of the 42-degree gearbox quill assembly. However, low readings were noted for these two bearings on 18 January and 6 May. No reason can be given for these two high readings.

UH-1D Helicopter, Serial No. 65-9773

The results of the inspections performed on the UH-1D helicopter Serial No. 65-9773, along with the time since overhaul of the various components, are as follows:

Date	1/17/68	1/22/68	2/15/68
Eng TSO (hrs)	611:00	622:00	629:00
Trans TSO (hrs)	611:00	622:00	629:00
90-Degree Gearbox TSO (hrs)	611:00	622:00	629:00
42-Degree Gearbox TSO (hrs)	22:00	33:00	40:00

On 17 January, at 611 flight hours total time, high readings (condition meter pegged) were observed for almost all bearings and gears of the power train, excluding the engine. These high readings were repeated after 11 flight hours on 22 January. As a result of the repeated high readings, a visual inspection was made that revealed severe oil leaks at the input quill. Between 22 January and 12 February, the following unscheduled maintenance was accomplished:

1. Adjusted cushion on N1 throttle
2. Adjusted linear actuator
3. Replaced input quill
4. Replaced short shaft
5. Adjusted trim tabs

Immediately upon completion of the above rework, on 15 February, after 7 additional flight hours, the aircraft was rerun and analyzed. All high readings had dropped to normal or below normal (see Tables I and III).

UH-1D Helicopter, Serial No. 65-9770

The results of the inspections performed on the UH-1D helicopter Serial No. 65-9770, along with the time since overhaul of the various components, are as follows:

Date	2/6/68	2/19/68	3/25/68
Eng TSO (hrs)	634:35	652:65	700:00
Trans TSO (hrs)	634:35	652:45	700:00
90-Degree Gearbox TSO (hrs)	634:35	652:45	700:00
42-Degree Gearbox TSO (hrs)	634:35	652:45	700:00

On 6 February, at 634:35 flight hours total time, high readings were noted for a number of main rotor bearings. The trim tabs and the pitch links were adjusted. On 19 February, at 652:45 flight hours total time, it was noted that although this maintenance eliminated some high readings, a number of pegs were still observed.

Prior to 25 March, a periodic maintenance inspection was performed. In addition to the normal maintenance, the pitch links were replaced because of excessive wear and the tail rotor was replaced.

On 25 March, at 700 flight hours total time, the aircraft was rerun and analyzed. The bearing readings for the main rotor, which previously read high, now read normal. This was assumed to be due to the replacement of the pitch links. The engine readings were consistently normal throughout the test (see Tables I and III).

UH-1B Helicopter, Serial No. 62-2101

The results of the inspections performed on the UH-1B helicopter Serial No. 62-2101, along with the time since overhaul of the various components, are as follows:

Date	2/19/68	2/23/68
Eng TSO (hrs)	250:00	254:00
Trans TSO (hrs)	101:00	105:00
90-Degree Gearbox TSO (hrs)	101:00	105:00
42-Degree Gearbox TSO (hrs)	1204:00	1208:00

On 19 February (total transmission time 1172 hours, TSO 101 hours), high readings were noted for the lower transmission input quill bearings, the lower transmission offset spur gear bearings, and the main rotor shaft upper and lower support bearings. On 21 February, the aircraft was re-run and analyzed. All previous high bearing readings read low except the third harmonic of the main rotor shaft upper support bearing. This reading still pegged but read 5db lower than previously. No further analysis could be made on this aircraft, as it crashed during a practice autorotation; the crash was not caused by mechanical failure.

UH-1B Helicopter, Serial No. 61-0778

The results of the inspections performed on the UH-1B helicopter Serial No. 61-0778, along with the time since overhaul of the various components, are as follows:

Date	2/23/68	3/8/68	3/28/68	4/8/68	4/23/68
Eng TSO (hrs)	5:00	6:00	20:35	26:05	37:05
Trans TSO (hrs)	682:00	683:00	697:35	703:05	714:05
90-Degree Gearbox TSO (hrs)	3:00	4:00	18:35	24:05	35:05
42-Degree Gearbox TSO (hrs)	3:00	4:00	18:35	24:05	35:05

At an aircraft total time of 942:05 hours, no abnormal readings were noted and no unscheduled maintenance was required.

UH-1D Helicopter, Serial No. 65-9771

The results of the inspections performed on the UH-1D helicopter Serial No. 65-9771, along with the time since overhaul of the various components, are as follows:

Date	3/11/68	3/15/68	3/19/68	3/22/68
Eng TSO (hrs)	634:00	639:00	639:00	639:00
Trans TSO (hrs)	640:00	645:00	645:00	645:00
90-Degree Gearbox TSO (hrs)	640:00	645:00	645:00	645:00
42-Degree Gearbox TSO (hrs)	640:00	645:00	645:00	645:00

Because of repeated excessive pilot-reported vibration, the maintenance branch requested a sonic analysis of this aircraft. On 11 March, and again 5 flight hours later on 15 March, sonic readings were taken. Both sets of readings indicated a number of high readings throughout the power train, excluding the engine. Past experience indicated that this type of analysis resulted because either the engine was out of alignment or the engine or transmission mounting bolts were loose. As the mounting bolts

reportedly had been checked, the aircraft was reanalyzed on 19 March. The previous high readings still existed. The aircraft was sent to the support branch for a complete check, and the following discrepancies were found and corrected:

1. Transmission mount bolts were loose (torque of 80 inch-pounds specified, found to be under 50 inch-pounds).

2. Engine and transmission were out of alignment .060 inch (maximum allowable .005 inch).

3. Engine-to-short-shaft adapter mounting bolt was finger tight and safety wired, resulting in excessive adapter end play (bolt torque should be 100 to 140 inch-pounds).

4. Main rotor blades were 1-1/2 inches out of track.

Prior to flight, this aircraft was reanalyzed on 22 March. All indications were normal or below. Subsequently, the test pilot reported that the excessive vibration, previously reported, had been corrected.

UH-1D Helicopter, Serial No. 65-9959

The results of the inspections performed on the UH-1D helicopter Serial No. 65-9959, along with the time since overhaul of the various components, are as follows:

Date	2/28/68	4/2/68	5/2/68
Eng TSO (hrs)	402:05	465:30	496:05
Trans TSO (hrs)	402:05	465:30	494:05
90-Degree Gearbox TSO (hrs)	402:05	465:30	496:05
42-Degree Gearbox TSO (hrs)	402:05	465:30	494:05

On 28 February, high readings were noted for a number of transmission and gearbox components. The engine readings were generally higher than those obtained for other aircraft, but they were below the reject point. Between this date and 2 April, a definite degradation was noted in the readings of the tail drive shaft support bearings (hanger bearings). Bearing readings for the 42-degree and 90-degree gearboxes were also higher. The following maintenance work was accomplished:

1. Replaced main rotor pitch link bearings

2. Replaced tail rotor pitch link bearings

3. Replaced No. 1 and No. 2 hanger bearings

4. Replaced main rotor hub and blades

After 28 additional flight hours, on 2 May the aircraft was checked. Readings were within acceptable limits, although the engine readings remained relatively high. It should be noted that since all four hanger bearings have identical frequencies and are physically located comparatively close to one another, the analyzer cannot distinguish which hanger bearing is discrepant. However, the analyzer can, and in this case did, indicate the existence of a discrepant hanger bearing.

UH-1D Helicopter, Serial No. 63-12992

The results of the inspections performed on the UH-1D helicopter Serial No. 63-12992, along with the time since overhaul of the various components, are as follows:

Date	3/19/68	4/4/68
Eng TSO (hrs)	768:15	771:45
Trans TSO (hrs)	768:15	771:45
90-Degree Gearbox TSO (hrs)	768:15	771:45
42-Degree Gearbox TSO (hrs)	768:15	771:45

At an aircraft total time of 771:45 hours, no abnormal readings were noted and no unscheduled maintenance was required.

UH-1D Helicopter, Serial No. 65-9772

The results of the inspections performed on the UH-1D helicopter Serial No. 65-9772, along with the time since overhaul of the various components, are as follows:

Date	4/9/68	4/19/68	5/2/68
Eng TSO (hrs)	624:25	650:00	669:10
Trans TSO (hrs)	624:25	650:00	669:10
90-Degree Gearbox TSO (hrs)	624:25	650:00	669:10
42-Degree Gearbox TSO (hrs)	624:25	650:00	669:10

At an aircraft total time of 669:10 hours, no abnormal readings were noted and no unscheduled maintenance was required.

UH-1D Helicopter, Serial No. 65-9739

The results of the inspections performed on the UH-1D helicopter Serial No. 65-9739, along with the time since overhaul of the various components, are as follows:

Date	4/8/68	4/10/68
Eng TSO (hrs)	578:30	583:00
Trans TSO (hrs)	578:30	583:00
90-Degree Gearbox TSO (hrs)	578:30	583:00
42-Degree Gearbox TSO (hrs)	578:30	583:00

At an aircraft total time of 583 hours, no abnormal readings were noted and no unscheduled maintenance was required.

UH-1B Helicopter, Serial No. 61-0713

The results of the inspections performed on the UH-1B helicopter Serial No. 61-0713, along with the time since overhaul of the various components, are as follows:

Date	4/17/68	4/23/68	5/14/68
Eng TSO (hrs)	246:15	251:30	270:15
Trans TSO (hrs)	2:15	7:30	26:15
90-Degree Gearbox TSO (hrs)	2:15	7:30	26:15
42-Degree Gearbox TSO (hrs)	2:15	7:30	26:15

At an aircraft total time of 1620:20 hours, no abnormal readings were noted and no unscheduled maintenance was required.

ANALYZER PERFORMANCE

At the start of the program, difficulty was experienced in obtaining a satisfactory "lock" on the N1 and N2 turbines and in calibrating the analyzer. The difficulty experienced was traced to a defective part, which was replaced by the contractor. Throughout the program, no further maintenance was required on the analyzer.

During the early part of the program, it was observed that when a high wind occurred (20 knots or above), it was extremely difficult to maintain the rpm of the gas producer section and the power turbine section sufficiently constant to analyze the power train. This was solved by heading the aircraft into the wind.

Throughout the test program, a number of inconsistent readings appeared (see Tables I, II, and III) for which a number of factors such as the following could have contributed:

1. Sudden wind gusts

2. Maintenance performed but inadvertently not reported

3. Operator's inexperience at the initiation of the program

4. Loss of "lock" at the time the reading was taken

The manufacturer of the analyzer noted that throughout the program there was a 70% to 80% confidence level that if the analyzer indicated a defective component in an engine, the defective component existed.

Item	Component		Mic Select	Lock Select	Ratio Set	Gain Set	Condition Limit	YUH-1D #60-6032			UH-1D #65-9773			
								1/18/68	2/14/68	5/6/68	1/17/68	1/22/68	2/15/68	2/6/
	Start													
	Clear						Set rpm Meter							
	N1 Cal		Cal	N1	.3321	5-5	Set Max							
	N2 Cal		Cal	N2	.3533	5-5	Set Max							
	Mic 3 Normalize		3	N1	1.1223	5-25	Set 5							
1	Tail Drive Shaft Support Brg	f_1	3	N2	.0304	1-5	Reject 8	3.5	2.5	7.5	5.0	6.0	6.5	6.
2	↓	f_2	3	N2	.0215	3-0	↓	4.5	0.5	4.5	5.5	5.5	4.5	6.
3		f_B'	3	N2	.0266	1-5		3.5	3.5	4.5	4.5	6.0	5.	5.
4	↓	$3f_B'$	3	N2	.1043	2-15		4.0	3.0	8.0	4.5	7.0	4.0	8.
5	42° Gearbox Quill Assy Brg	f_1	3	N2	.0376	5-10		5.0	P15	6.5	7.5	8.5	7.0	10.
6	↓	f_2	3	N2	.0257	1-5		4.0	3.5	5.5	5.5	6.5	6.0	5.
7		f_B'	3	N2	.0241	1-5		8.0	5.0	5.0	5.0	5.5	5.0	6.
8	↓	$3f_B'$	3	N2	.0743	5-5		8.0	3.5	5.0	6.0	6.0	3.5	6.
9	42° and 90° Gearbox Quill Brg	f_1	3	N2	.0341	3-10		3.5	10.0	5.5	7.0	9.0	7.5	7.
10	↓	f_2	3	N2	.0217	3-0		4.0	6.0	5.0	6.0	5.5	7.0	6.
11		f_B'	3	N2	.0203	3-0		2.5	5.5	4.0	4.5	4.0	4.5	4.
12	↓	$3f_B'$	3	N2	.0611	3-10		3.0	4.5	6.5	6.5	6.5	6.5	5.
13	42° Gearbox Bevel Gears, Fundamental		3	N2	.1474	4-0	↓	6.5	7.5	5.0	9.5	9.5	4.5	5.5
	Noise Check (Storage)		3	N2	.1553	4-0								
14	42° Gearbox Bevel Gears, Fundamental		3	N2	.1474	4-0		6.0	7.5	8.5	P	9.0	3.0	5.5
15	↓	$-f_R$	3	N2	.1436	4-0	Reject 1/2 of 14	2.0	1.5	2.5	7.5	5.0	3.5	3.5
16		$+f_R$	3	N2	.1533	4-0	↓	1.0	2.5	2.0	5.5	3.0	1.5	4.0
17	↓	X2	3	N2	.3171	4-0		1.0	0.5	5.0	5.0	5.5	2.5	3.5
	Clear		-	-	-	-								
18	90° Gearbox Bevel Gears, Fundamental		3	N2	.0714	2-0	Reject 8	7.5	6.0	8.0	P	9.0	8.0	4.5
	Noise Check (Storage)		3	N2	.0773	2-0								
19	90° Gearbox Bevel Gears, Fundamental		3	N2	.0714	2-0		7.5	4.5	8.0	P	8.5	4.5	5.0
20	↓	$-f_R$	3	N2	.0655	2-0	Reject 1/2 of 19	2.0	1.5	4.5	6.0	4.5	3.5	2.5

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TABLE I. AUTOMATIC TAPE NO. 109 READINGS FOR SELECTED COMPONENTS

Condition Level																		
UH-1D #65-9770			UH-1B #62-2101		UH-1B #61-0778					UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-1	
/68	2/19/68	3/25/68	2/19/68	2/23/68	2/23/68	3/8/68	3/28/68	4/8/68	4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/
5	5.5	4.5	3.0	3.0	2.0	4.5	3.0	3.5	7.5	9.5	6.5	4.5	6.5	6.5	9.5	4.0	7.5	
0	6.5	5.0	5.5	5.0	3.0	5.0	5.0	7.5	7.0	7.5	7.0	4.5	5.5	6.5	7.5	5.0	6.5	
0	4.0	4.0	2.0	3.5	2.5	3.5	2.0	3.0	5.0	8.0	5.5	4.0	4.5	4.5	6.5	2.0	7.5	
5	6.0	9.5	8.5	1.5	1.5	7.5	5.5	4.5	7.5	9.5	7.5	3.0	7.5	5.5	9.0	6.0	4.5	
0	6.0	7.0	3.5	5.0	2.5	6.5	5.5	6.5	7.5	P15	P10	6.5	9.0	6.5	10.0	5.0	7.0	
5	6.0	5.5	2.5	3.5	2.0	3.5	5.0	2.5	3.5	8.5	6.5	3.5	6.0	5.5	6.5	5.0	9.5	
0	5.0	7.0	2.5	3.5	2.0	5.0	3.0	2.5	4.0	9.0	7.5	6.0	5.5	5.0	6.5	4.5	9.5	
5	4.0	7.5	4.5	3.5	2.0	6.0	7.5	6.5	P12	7.5	8.5	3.5	1.0	5.0	8.5	6.0	P15	
0	3.5	8.5	2.5	3.5	4.5	5.5	4.5	5.0	7.5	P13	P10	6.5	7.5	6.5	10.5	3.0	6.5	
5	4.0	5.5	2.5	4.0	4.5	5.0	5.5	8.0	8.5	6.5	7.0	4.0	5.5	7.5	7.5	5.0	4.0	
5	3.5	4.5	1.5	3.0	2.5	2.5	3.0	4.0	4.0	6.0	5.5	3.5	4.5	4.5	5.0	2.5	4.5	
0	2.5	8.5	4.0	3.0	7.0	5.5	7.0	5.5	7.5	P15	P10	6.0	P	4.5	P10	5.0	5.5	
5	3.5	P	7.0	7.5	3.0	5.0	8.5	5.0	7.0	6.5	6.0	7.0	7.5	9.0	9.5	8.5	6.5	
5	1.5	P	7.5	7.5	3.0	5.5	8.5	5.0	7.0	6.5	7.5	8.0	7.0	9.0	10.5	8.5	6.5	
5	1.0	3.5	2.5	2.0	1.5	2.5	3.0	1.5	2.5	3.5	6.5	6.5	4.5	3.5	3.5	3.0	2.0	
0	0.5	4.0	4.0	2.5	2.0	4.0	6.0	2.5	4.5	4.0	4.5	2.0	3.5	4.0	4.0	1.5	1.5	
5	0.5	4.5	1.5	0.5	2.5	2.0	3.0	3.5	4.5	5.0	3.5	1.5	5.5	3.5	6.5	3.0	1.5	
5	7.0	7.5	8.0	5.0	9.5	9.5	P	8.5	P	9.5	7.0	4.5	9.5	P	P	9.5	10.0	
0	7.5	9.0	8.0	5.0	9.5	9.5	P	8.0	P	9.5	8.0	4.5	9.5	P	10.0	9.5	9.5	
5	2.0	3.0	1.5	1.0	3.0	3.0	5.0	5.0	4.5	3.5	1.5	2.5	4.0	2.5	5.5	2.5	1.5	

Condition Level																	
	UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-12992		UH-1D #65-9772			UH-1D #65-9739		UH-1B #61-0713		
3/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4/68	4/9/68	4/19/68	5/2/68	4/8/68	4/10/68	4/17/68	4/23/68	5/14/68
.5	9.5	6.5	4.5	6.5	6.5	9.5	4.0	7.5	6.5	3.5	4.5	6.0	8.5	8.0	2.0	5.5	4.0
.0	7.5	7.0	4.5	5.5	6.5	7.5	5.0	6.5	5.0	7.5	6.5	7.0	3.5	6.5	2.5	6.5	3.0
.0	8.0	5.5	4.0	4.5	4.5	6.5	2.0	7.5	4.5	3.0	3.5	5.0	6.0	6.5	2.5	4.0	2.0
.5	9.5	7.5	3.0	7.5	5.5	9.0	6.0	4.5	6.0	4.0	6.5	P15	P	1.0	4.0	7.5	3.0
.5	P15	P10	6.5	9.0	6.5	10.0	5.0	7.0	8.0	5.5	6.5	8.5	P	1.0	4.5	7.5	4.5
.5	8.5	6.5	3.5	6.0	5.5	6.5	5.0	9.5	5.5	4.0	5.5	5.5	8.5	6.5	3.0	4.5	2.5
.0	9.0	7.5	6.0	5.5	5.0	6.5	4.5	9.5	6.0	4.0	6.5	5.5	7.5	7.0	3.5	4.5	2.5
12	7.5	8.5	3.5	1.0	5.0	8.5	6.0	P15	7.5	6.5	6.5	P	8.5	8.5	3.0	6.5	3.0
.5	P13	P10	6.5	7.5	6.5	10.5	3.0	6.5	7.0	5.5	7.5	P12	P	8.5	4.5	6.5	5.0
.5	6.5	7.0	4.0	5.5	7.5	7.5	5.0	4.0	5.5	4.5	5.5	7.5	6.5	6.5	3.0	6.5	2.5
.0	6.0	5.5	3.5	4.5	4.5	5.0	2.5	4.5	5.0	3.5	3.5	5.5	5.0	6.0	3.0	4.0	2.5
5	P15	P10	6.0	P	4.5	P10	5.0	5.5	8.5	8.5	7.0	P15	P	P	4.5	8.5	4.5
0	6.5	6.0	7.0	7.5	9.0	9.5	8.5	6.5	9.0	6.5	10.0	7.0	6.5	10.0	6.5	P	5.0
0	6.5	7.5	8.0	7.0	9.0	10.5	8.5	6.5	9.0	6.5	10.0	3.0	6.5	10.0	5.5	10.0	5.0
5	3.5	6.5	6.5	4.5	3.5	3.5	3.0	2.0	4.5	2.0	3.0	9.5	5.0	4.5	3.0	6.0	3.0
5	4.0	4.5	2.0	3.5	4.0	4.0	1.5	1.5	7.5	1.5	1.5	3.0	4.0	4.5	2.5	4.0	1.5
5	5.0	3.5	1.5	5.5	3.5	6.5	3.0	1.5	4.5	3.0	2.0	6.0	3.5	4.5	1.5	3.0	1.5
	9.5	7.0	4.5	9.5	P	P	9.5	10.0	P	10.0	9.5	9.5	9.5	10.0	6.5	9.5	3.5
	9.5	8.0	4.5	9.5	P	10.0	9.5	9.5	P	9.5	9.5	9.5	9.5	9.5	6.0	9.5	3.5
5	3.5	1.5	2.5	4.0	2.5	5.5	2.5	1.5	4.5	4.0	4.5	5.0	5.0	4.5	3.0	6.0	3.0

C

Item	Component		Mic Select	Lock Select	Ratio Set	Gain Set	Condition Limit	YUH-1D #60-6032			UH-1D #65-9773			U
								1/18/68	2/14/68	5/6/68	1/17/68	1/22/68	2/15/68	2/6/68
21	90° Gearbox Bevel Gears, Fundamental	$+f_R$	3	N2	.0753	2-0	Reject 1/2 of 19	2.5	1.5	3.0	6.0	3.5	1.5	3.5
22	↓	X2	3	N2	.1630	2-0	↓	1.5	1.0	4.0	8.0	6.5	2.0	8.0
	Mic 1 Normalize		1	N1	1.1223	5-25	Set 5							
23	Main Rotor Low-Speed Gears		1	N2	.0423	5-15	Reject 8	2.0	2.3	4.0	P	P17	2.5	4.0
24	↓	X2	1	N2	.1046	5-15		1.0	1.0	1.0	6.0	P5	1.0	1.5
25	Lower Transmission Output Drive Gears		1	N2	.1435	3-15		0.5	1.0	1.0	4.0	P13	1.0	1.5
26	↓	X2	1	N2	.3072	3-15		0.5	1.0	1.0	5.5	5.5	1.0	1.5
27	Main Rotor High-Speed Gears		1	N2	.1520	5-15		0.5	1.5	1.0	4.5	8.5	1.0	3.5
28	Lower Transmission Offset Spur Gears		1	N2	.2273	5-15		1.0	2.5	6.0	5.5	P13	1.5	3.5
29	Input Drive Bevel Gears		1	N2	.2525	5-5		0.5	1.5	2.0	6.5	P10	2.0	3.5
30	↓	X2	1	N2	.5253	1-15		0.5	0.5	1.0	2.5	2.0	1.0	1.0
31	Oil Pump		1	N2	.0166	5-10		2.0	2.0	P13	P	P15	2.5	3.0
32	Swash Plate Brg, UH-1A/1B/1C	f_1	1	N2	.0145	5-10		6.0	2.0	1.5	P	P15	2.5	3.0
33	↓	f_2	1	N2	.0137	5-10		2.5	2.5	1.5	P	P15	3.0	3.5
34	↓	f_B'	1	N2	.0107	5-5		4.0	3.5	2.5	7.0	7.5	2.0	3.5
35	↓	$3f_B'$	1	N2	.0325	5-15		1.5	2.5	1.0	P	P20	3.5	4.5
36	Main Rotor Shaft Upper Support Brg	f_1	1	N2	.0032	5-20		6.0	5.0	4.5	P	P15	1.5	P
37	↓	f_2	1	N2	.0024	5-20		3.5	4.5	4.5	P	P20	1.5	P
38	↓	f_B'	1	N2	.0021	5-20		3.0	3.5	4.0	P	P21	1.0	P
39	↓	$3f_B'$	1	N2	.0062	5-20		6.5	7.0	P19	P	R25	7.0	P
40	Main Rotor Shaft Lower Support Brg	f_1	1	N2	.0043	5-20		2.5	6.0	P23	P	P19	6.5	P
41	↓	f_2	1	N2	.0035	5-20		6.0	5.0	7.0	P	P15	5.5	P
42	↓	f_B'	1	N2	.0031	5-20		5.0	5.5	4.0	P	P20	3.0	P
43	↓	$3f_B'$	1	N2	.0112	5-10		2.0	1.0	4.5	P	P25	4.5	3.0
44	Input Quill Assy Single-Row Brg	f_1	1	N2	.1056	5-20		1.0	1.0	1.0	P	P16	3.0	4.0
45	↓	f_2	1	N2	.0736	5-20		2.0	1.5	1.0	P	P21	2.5	4.0
46	↓	f_B	1	N2	.1133	5-20		1.0	1.5	1.0	P	P14	2.0	2.5
47	↓	$3f_B'$	1	N2	.3421	5-20	↓	1.0	0.5	1.5	7.5	9.5	3.0	2.5

A

TABLE 1. CONTINUED

Condition Level																		
UH-1D #65-9770			UH-1B #62-2101		UH-1B #61-0778					UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-1	
/68	2/19/68	3/25/68	2/19/68	2/23/68	2/23/68	3/8/68	3/28/68	4/8/68	4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/
.5	1.5	5.5	2.0	1.5	1.5	5.0	5.0	5.0	5.5	3.5	3.5	2.0	4.5	4.5	5.5	3.5	2.0	
0	2.0	6.5	1.5	1.5	5.0	6.5	5.0	3.5	6.5	3.5	2.5	4.0	2.5	7.5	6.5	2.5	7.5	
0	P	3.5	2.0	1.5	1.5	1.5	1.0	1.5	1.5	3.5	5.5	3.0	2.0	3.5	4.5	5.5	5.0	
5	4.0	1.5	5.5	1.5	1.5	1.5	2.0	1.0	2.5	1.5	3.5	2.0	1.0	2.0	1.5	1.0	2.5	
5	6.5	2.5	7.0	6.0	2.5	2.0	1.0	2.5	2.5	1.5	3.0	4.5	1.0	1.5	2.0	1.0	1.5	
5	3.0	1.5	4.5	2.0	-1.0	2.0	1.0	1.5	1.5	1.0	2.0	1.0	1.0	1.5	1.5	1.0	1.5	
5	3.0	1.5	1.5	2.0	0.5	1.5	1.0	1.0	1.0	1.0	2.5	1.0	2.0	1.5	1.5	1.0	1.0	
5	3.5	2.0	3.5	1.5	1.5	1.5	1.5	1.5	1.5	1.0	3.0	1.5	1.0	1.0	2.0	1.0	1.5	
5	7.0	2.5	3.5	7.5	2.0	4.5	3.5	3.0	2.0	5.5	6.5	2.5	2.5	2.5	3.0	4.5	2.0	1
0	1.5	1.5	2.5	3.0	0.5	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1
0	8.5	3.0	1.5	1.0	1.0	2.0	1.0	1.5	1.5	3.0	5.0	3.5	2.0	2.5	2.5	P15	3.5	1
0	9.5	2.5	2.5	1.0	1.5	1.5	1.0	1.5	1.5	4.0	5.5	3.5	1.5	3.0	4.0	1.5	4.0	1
5	6.5	2.0	4.0	1.0	1.5	1.5	1.5	2.0	1.5	2.5	5.5	3.5	2.5	3.5	5.0	2.0	4.5	1
5	5.5	1.5	3.5	1.5	2.0	2.0	1.5	2.5	2.0	1.5	3.5	1.5	1.0	2.5	2.5	1.0	2.5	1
5	9.5	2.0	2.0	0.5	1.0	1.0	1.0	1.5	1.5	2.5	5.5	3.0	2.0	3.5	4.5	1.0	4.5	1
	P10	2.5	9.5	2.0	4.0	3.0	3.5	5.0	5.0	P9	3.5	3.0	1.0	4.0	3.5	2.5	P16	6
	P7	2.5	5.0	1.5	3.0	3.5	1.5	4.0	3.5	2.0	2.0	2.5	1.0	3.5	2.0	2.5	P9	4
	P5	1.5	5.5	1.0	1.0	2.0	2.5	2.5	2.5	1.5	1.5	2.0	1.0	3.5	2.0	2.5	9.5	2
	P20	7.5	P25	P20	3.5	4.5	5.5	6.5	6.5	P15	P	P21	8.5	P	P19	P14	P20	4
	P15	2.5	P18	2.0	2.5	P5	3.5	5.5	4.5	5.0	5.5	4.5	1.5	5.0	P14	P20	P9	4
	P14	3.5	P14	2.5	2.5	P5	2.5	4.5	4.5	4.5	3.5	4.5	1.5	5.5	5.5	3.5	P6	4
	P9	2.5	P10	3.0	2.0	8.5	2.5	4.5	3.5	4.0	2.5	4.5	2.5	3.5	4.5	2.5	P9	2
)	7.5	2.0	6.0	2.5	2.0	6.5	2.0	3.0	3.0	2.5	5.0	2.0	2.0	3.0	4.0	2.5	4.5	1
)	5.5	1.5	8.5	1.5	2.0	9.5	3.0	2.0	2.5	2.0	6.0	2.0	1.5	2.5	2.5	1.5	4.5	1
)	8.0	2.0	5.0	1.0	1.5	5.5	2.0	2.0	1.5	2.5	5.0	3.0	1.5	3.0	3.5	1.5	4.5	1
	4.5	1.0	3.0	1.0	1.0	6.5	1.0	1.0	1.0	2.0	3.0	1.5	1.0	1.5	2.5	1.0	3.5	1
	6.5	1.0	8.0	1.5	1.5	5.0	2.0	1.5	1.0	2.0	4.5	2.5	1.0	2.5	2.5	1.0	2.0	1

B

Condition Level	UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-12992		UH-1D #65-9772			UH-1D #65-9739		UH-1B #61-0713		
4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4/68	4/9/68	4/19/68	5/2/68	4/8/68	4/10/68	4/17/68	4/23/68	5/14/68
5.5	3.5	3.5	2.0	4.5	4.5	5.5	3.5	2.0	4.0	5.5	4.0	7.5	5.0	3.5	3.5	4.0	1.5
6.5	3.5	2.5	4.0	2.5	7.5	6.5	2.5	7.5	1.5	7.5	3.5	3.5	5.5	8.5	4.5	7.5	5.0
1.5	3.5	5.5	3.0	2.0	3.5	4.5	5.5	5.0	1.5	2.5	2.5	5.5	2.5	2.0	1.5	1.5	2.0
2.5	1.5	3.5	2.0	1.0	2.0	1.5	1.0	2.5	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.0
2.5	1.5	2.0	4.5	1.0	1.5	2.0	1.0	1.5	1.0	2.5	1.0	1.5	1.0	1.0	3.5	2.0	2.0
1.5	1.0	2.0	1.0	1.0	1.5	1.5	1.0	1.5	1.0	1.5	1.5	2.0	1.0	1.0	1.0	1.5	3.0
1.0	1.0	2.5	1.0	2.0	1.5	1.5	1.0	1.0	1.0	1.0	1.0	1.5	1.0	1.0	1.0	1.0	1.0
1.5	1.0	3.0	1.5	1.0	1.0	2.0	1.0	1.5	1.0	1.0	1.0	1.0	1.0	2.0	1.0	1.5	1.5
2.0	5.5	6.5	2.5	2.5	2.5	3.0	6.5	2.0	2.0	3.5	2.5	4.5	1.0	3.0	1.0	1.5	2.0
1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.5	3.0	5.0	3.5	2.0	2.5	2.5	P15	3.5	2.0	1.5	3.0	P9	2.0	2.0	1.0	1.0	7.5
1.5	4.0	5.5	3.5	1.5	3.0	4.0	1.5	4.0	1.5	2.0	2.5	2.0	2.0	2.5	2.0	2.0	1.5
1.5	2.5	5.5	3.5	2.5	3.5	5.0	2.0	4.5	2.0	2.5	2.0	2.0	2.0	3.0	2.5	2.0	1.5
2.0	1.5	3.5	1.5	1.0	2.5	2.5	1.0	2.5	1.0	1.5	1.5	2.0	1.0	1.5	1.0	1.5	1.5
1.5	2.5	5.5	3.0	2.0	3.5	4.5	1.0	4.5	1.5	2.5	3.5	2.5	2.5	2.5	1.5	1.0	1.0
5.0	P9	3.5	3.0	1.0	4.0	3.5	2.5	P16	6.0	2.5	3.0	3.0	2.0	4.5	2.5	3.5	5.5
3.5	2.0	2.0	2.5	1.0	3.5	2.0	2.5	P9	4.5	1.5	2.5	3.5	1.5	3.0	1.5	2.5	6.0
2.5	1.5	1.5	2.0	1.0	3.5	2.0	2.5	9.5	2.5	1.5	1.5	2.5	1.5	2.5	1.5	2.5	4 5
6.5	P15	P	P21	8.5	P	P19	P14	P20	4.5	9.5	P5	P20	P	P	P17	P18	P25
4.5	5.0	5.5	4.5	1.5	5.0	P14	P20	P9	4.5	2.5	3.5	P20	3.5	4.5	2.5	3.0	P25
4.5	4.5	3.5	4.5	1.5	5.5	5.5	3.5	P6	4.0	2.5	4.5	8.5	2.0	5.0	2.5	2.0	10.0
3.5	4.0	2.5	4.5	2.5	3.5	4.5	2.5	P9	2.5	3.0	4.5	2.5	2.0	3.5	1.5	4.5	6.0
3.0	2.5	5.0	2.0	2.0	3.0	4.0	2.5	4.5	1.5	2.5	2.5	4.0	2.0	2.0	2.0	1.5	5.5
2.5	2.0	6.0	2.0	1.5	2.5	2.5	1.5	4.5	1.0	1.5	1.5	1.5	1.5	2.0	4.5	2.0	2.0
1.5	2.5	5.0	3.0	1.5	3.0	3.5	1.5	4.5	1.5	1.5	1.5	1.5	1.0	2.0	P15	2.5	1.0
1.0	2.0	3.0	1.5	1.0	1.5	2.5	1.0	3.5	1.0	1.5	1.5	1.0	1.0	1.0	1.0	1.0	1.0
1.0	2.0	4.5	2.5	1.0	2.5	2.5	1.0	2.0	1.0	1.0	2.0	1.5	3.5	1.5	1.0	1.0	1.0

C

Component		Mic Select	Lock Select	Ratio Set	Gain Set	Condition Limit	YUH-1D #60-6032			UH-1D #65-9773			UH-1D #	
							1/18/68	2/14/68	5/6/68	1/17/68	1/22/68	2/15/68	2/6/68	2/1
Tail Rotor and Accessory Output Quil Assy Brg	f_1	1	N2	.0341	5-15	Reject 8	1.5	1.0	1.5	P	P20	4.5	4.5	7.
	f_2	1	N2	.0217	5-15		3.5	2.0	2.0	P	P20	5.0	5.0	10.
	f_B'	1	N2	.0203	5-15		2.0	2.0	1.5	P	P20	5.5	5.5	10.
	$3f_B'$	1	N2	.0611	5-25		4.0	1.0	2.5	P	P25	4.5	5.0	P
Main Rotor Low-Speed Carrier Support Brg	f_1	1	N2	.0072	5-15		4.5	3.0	3.0	P	P20	5.5	4.0	P
	f_2	1	N2	.0065	5-15		5.5	4.0	6.0	P	P20	5.0	P	P
	f_B'	1	N2	.0055	5-15		5.0	3.5	P	P	P20	2.5	P	P
	$3f_B'$	1	N2	.0210	5-15		3.5	2.0	2.5	P	P20	2.5	5.0	P
Lower Transmission Input Quill Assy Brg	f_1	1	N2	.0365	3-15		2.5	1.5	1.5	P	P17	2.0	3.0	7.
	f_2	1	N2	.0251	3-15		2.5	2.0	2.5	P	P18	1.5	7.0	P
	f_B'	1	N2	.0234	3-15		2.5	2.5	6.5	P	P18	2.0	2.5	9.
	$3f_B'$	1	N2	.0722	5-20		2.0	1.5	1.5	P	P19	1.5	4.0	8.

1 through 22 and 48 through 51 refer to numbers in parentheses in Figure 10.
23 through 47 and 52 through 59 refer to numbers in parentheses in Figure 9.

TABLE I. CONTINUED

	Condition Level																	
	UH-1D #65-9770			UH-1B #62-2101		UH-1B #61-0778					UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-12
58	2/19/68	3/25/68	2/19/68	2/23/68	2/23/68	3/8/68	3/28/68	4/8/68	4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4
5	7.5	1.5	2.5	1.0	2.0	5.5	1.5	1.0	1.5	3.5	6.0	2.5	2.0	4.5	4.5	1.5	6.5	1.
)	10.0	2.5	2.5	1.0	1.0	5.0	2.0	1.5	1.5	5.0	8.0	3.5	2.5	5.5	6.5	2.0	7.5	2.
5	10.0	2.5	2.5	0.5	1.0	6.0	3.0	1.5	1.5	4.0	7.5	3.5	2.5	5.0	5.5	3.0	8.5	2.
)	P14	2.0	3.5	1.0	1.5	9.0	2.5	10.0	1.0	4.0	P15	3.5	1.5	4.5	4.5	1.5	P11	3.
)	P10	3.5	6.5	2.5	2.5	5.5	4.5	3.5	3.5	4.5	7.0	3.5	3.0	5.0	6.0	2.0	P5	3.
	P15	5.5	P18	8.0	3.0	5.5	3.0	4.5	3.5	6.5	8.0	7.5	4.0	5.5	6.0	6.5	9.5	2.
	P14	3.5	8.5	5.0	2.5	10.0	3.0	4.5	4.0	5.0	6.5	4.5	3.5	4.5	7.0	P	9.5	3.
)	P14	2.5	2.5	1.0	1.0	2.5	2.0	1.5	1.0	4.0	7.0	2.5	3.0	4.0	5.5	2.0	7.5	2.
)	7.5	1.5	2.5	1.0	1.5	4.5	1.5	1.5	1.5	3.5	6.0	2.0	1.5	4.0	3.5	1.5	6.5	1.
)	P18	6.0	2.5	0.5	0.5	3.5	1.5	1.0	2.5	6.5	P18	P19	3.5	3.5	4.5	1.5	P7	3.
)	9.0	1.5	P18	5.0	2.0	P11	2.0	1.0	1.0	4.5	6.5	4.0	2.0	3.5	4.5	3.0	6.5	1.
)	8.5	2.0	P17	3.5	2.0	5.5	1.5	2.5	1.5	3.0	5.5	2.5	2.0	3.0	3.5	1.0	5.5	1.

B

Condition Level																	
	UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-12992		UH-1D #65-9772			UH-1D #65-9739		UH-1B #61-0713		
/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4/68	4/9/68	4/19/68	5/2/68	4/8/68	4/10/68	4/17/68	4/23/68	5/14/68
5	3.5	6.0	2.5	2.0	4.5	4.5	1.5	6.5	1.5	2.0	3.5	1.5	2.0	3.0	1.5	1.0	1.0
5	5.0	8.0	3.5	2.5	5.5	6.5	2.0	7.5	2.0	3.0	3.5	3.0	3.0	3.0	1.5	1.0	1.0
5	4.0	7.5	3.5	2.5	5.0	5.5	3.0	8.5	2.0	2.5	4.0	3.5	2.5	3.5	1.5	1.0	1.0
0	4.0	P15	3.5	1.5	4.5	4.5	1.5	P11	3.0	2.5	3.5	2.5	1.5	8.5	1.0	1.0	1.0
5	4.5	7.0	3.5	3.0	5.0	6.0	2.0	P5	3.5	3.0	4.5	4.5	3.5	3.5	2.5	2.5	3.0
5	6.5	8.0	7.5	4.0	5.5	6.0	6.5	9.5	2.5	5.5	6.5	4.0	6.0	4.5	P12	8.5	9.5
0	5.0	6.5	4.5	3.5	4.5	7.0	P	9.5	3.5	3.5	5.5	P	3.0	4.0	5.5	5.5	P
0	4.0	7.0	2.5	3.0	4.0	5.5	2.0	7.5	2.5	3.0	3.5	3.5	3.0	4.0	1.0	1.0	1.0
5	3.5	6.0	2.0	1.5	4.0	3.5	1.5	6.5	1.5	1.5	3.0	2.5	2.0	2.0	1.0	1.0	1.0
5	6.5	P18	P19	3.5	3.5	4.5	1.5	P7	3.0	3.0	4.0	4.0	3.0	3.5	1.0	2.5	2.0
0	4.5	6.5	4.0	2.0	3.5	4.5	3.0	6.5	1.5	2.0	3.5	4.5	2.5	2.5	1.5	1.5	1.5
5	3.0	5.5	2.5	2.0	3.0	3.5	1.0	5.5	1.5	1.5	2.0	1.5	1.5	2.0	1.0	1.5	1.0

C

TABLE II.

Item	Component		Mic Select	Lock Select	Ratio Set	Gain Set	Condition Limit	YUH-1D #60-6032 1/18/68	YUH-1D #60-6032 2/14/68	YUH-1D #60-6032 5/6/68	UH-1D #65-9773 1/17/68	UH-1D #65-9773 1/22/68	UH-1D #65-9773 2/15/68	UH- 2/6/68
	Start													
	Clear						**Set rpm Meter**							
	N1 Cal		**Cal**	**N1**	**.3321**	**5-5**	**Set Max**							
	N2 Cal		**Cal**	**N2**	**.3533**	**5-5**	**Set Max**							
	Mic 2 Normalise		**2**	**N1**	**1.1223**	**5-25**	**Set 5**							
	Noise Check (Storage)		**2**	**N1**	**1.1223**	**5-25**								
1	**No. 2 Compressor, Fundamental**		**2**	**N1**	**1.0000**	**5-5**		**6.0**	**4.5**	**3.0**	**6.5**	**5.5**	**5.0**	**8.5**
2	↓	$-f_R$	**2**	**N1**	**.7556**	**5-5**		**0.5**	**1.5**	**1.0**	**2.0**	**1.0**	**0.5**	**0.5**
3	↓	$+f_R$	**2**	**N1**	**1.0222**	**5-5**		**0.5**	**1.0**	**1.0**	**1.5**	**0.5**	**0.5**	**1.0**
	Clear		-	-	-									
4	**No. 1 Main Brg**	f_1	**2**	**N1**	**.2142**	**2-25**	**Reject 8**	**2.5**	**6.5**	**4.0**	**1.0**	**6.5**	**2.5**	**6.0**
5	↓	f_2	**2**	**N1**	**.1413**	**2-25**	↓	**2.5**	**7.0**	**3.0**	**1.0**	**2.5**	**2.5**	**3.0**
6	↓	f_B'	**2**	**N1**	**.1420**	**2-25**	↓	**2.0**	**6.5**	**3.5**	**0.5**	**3.0**	**2.0**	**3.0**
7	↓	$3f_B'$	**2**	**N1**	**.4462**	**2-25**	↓	**3.0**	**6.5**	**4.5**	**1.0**	**1.0**	**2.0**	**3.0**
8	**No. 1 Main Brg (Option)**	f_1	**2**	**N1**	**.2272**	**2-25**	↓	**3.5**	**5.0**	**3.0**	**2.0**	**1.5**	**2.0**	**2.0**
9	↓	f_2	**2**	**N1**	**.1506**	**2-25**	↓	**2.5**	**4.0**	**2.0**	**1.0**	**1.5**	**1.5**	**1.5**
10	↓	$3f_B'$	**2**	**N1**	**.4444**	**2-25**	↓	**2.5**	**7.0**	**3.5**	**1.5**	**1.5**	**2.0**	**4.5**
11	**No. 2 Main Brg**	f_1	**2**	**N1**	**.3155**	**5-20**	↓	**3.3**	**6.0**	**3.0**	**1.5**	**1.0**	**2.5**	**4.5**
12	↓	f_2	**2**	**N1**	**.2400**	**5-20**	↓	**2.5**	**6.0**	**5.5**	**1.0**	**2.0**	**2.0**	**5.0**
13	↓	f_B'	**2**	**N1**	**.2210**	**5-20**	↓	**3.5**	**8.5**	**3.5**	**1.0**	**2.0**	**2.5**	**6.5**
14	↓	$3f_B'$	**2**	**N1**	**.6631**	**5-25**	↓	**3.5**	**6.0**	**5.0**	**4.0**	**2.5**	**3.0**	**5.0**
15	**No. 2 Main Brg (Option)**	f_1	**2**	**N1**	**.2450**	**5-20**	↓	**7.5**	**3.0**	**5.5**	**1.0**	**1.5**	**1.5**	**6.5**
16	↓	f_B'	**2**	**N1**	**.2146**	**5-20**	↓	**5.5**	**3.5**	**5.5**	**0.5**	**2.0**	**2.0**	**7.5**
17	↓	$3f_B'$	**2**	**N1**	**.6463**	**5-25**	↓	**7.5**	**3.0**	**5.5**	**2.5**	**3.0**	**1.5**	**10.0**
18	**Oil Pump (Vane Type)**		**2**	**N1**	**.0137**	**5-15**	↓	**5.5**	**5.5**	**2.5**	**3.5**	**P5**	**4.5**	**3.5**
19	**Oil Pump (Gear Type)**		**2**	**N1**	**.0355**	**5-20**	↓	**4.5**	**5.5**	**2.0**	**4.0**	**P9**	**3.5**	**1.0**
20	**Fuel Control Pump Gears**		**2**	**N1**	**.0370**	**5-25**	↓	**8.5**	**10.0**	**4.5**	**4.5**	**P15**	**6.0**	**3.0**
21	**Fuel Control Accessory Drive Gears**		**2**	**N1**	**.0565**	**5-25**	↓	**4.5**	**5.5**	**2.5**	**2.0**	**9.5**	**2.5**	**2.0**

A

AUTOMATIC TAPE NO. 110 READINGS FOR ENGINE MODELS T53-L-9, T53-L-9A,AND T53-L-11

Condition Level																	
-1D #65-9770		UH-1B #62-2101		UH-1B #61-0778					UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-12992	
2/19/68	3/25/68	2/19/68	2/23/68	2/23/68	3/8/68	3/28/68	4/8/68	4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4/68
P	5.5	3.0	4.5	4.5	6.0	7.5	5.0	6.5	4.0	9.5	P10	3.5	7.0	7.5	2.5	5.0	4.5
1.5	1.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.0	1.0	1.0	1.5	1.0	1.0	1.0	1.0
2.0	1.0	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3.5	5.5	2.5	6.5	4.5	3.5	4.0	2.5	2.5	4.0	3.5	5.5	3.0	6.0	4.0	8.0	2.5	3.5
4.5	5.5	P	7.5	4.0	7.5	4.0	2.0	4.0	P13	5.5	2.0	3.5	5.5	3.5	5.5	2.0	2.5
4.5	7.0	P	6.5	4.5	5.5	5.5	3.0	3.5	9.0	5.0	2.5	3.0	7.0	4.5	6.0	2.0	4.5
3.5	9.0	1.5	8.0	6.0	7.5	5.5	3.0	3.5	4.5	3.5	3.5	4.5	8.0	4.5	6.5	1.5	5.5
4.0	7.5	1.5	7.5	3.5	6.0	5.0	3.5	5.0	6.5	4.5	7.5	4.5	4.5	6.0	7.5	2.5	4.5
4.0	4.5	3.5	9.0	6.0	8.5	5.0	1.5	2.0	2.0	3.0	3.0	3.5	6.5	2.0	5.5	2.0	2.5
3.5	8.5	1.5	7.5	4.0	6.5	5.5	1.0	3.5	2.0	4.5	5.5	5.0	6.5	5.0	5.0	2.0	5.5
3.5	8.5	2.5	8.5	8.5	6.0	6.5	1.0	2.5	3.0	6.0	6.5	5.0	9.5	5.5	6.5	1.5	4.5
4.0	7.5	2.0	7.5	6.5	P8	3.5	1.0	3.0	2.0	6.0	7.5	4.5	6.5	6.5	5.0	2.0	5.0
3.5	6.0	2.0	6.5	4.5	5.0	4.0	2.5	2.5	4.0	7.0	5.5	4.0	5.0	5.0	7.5	2.5	4.0
7.5	9.5	2.0	7.0	6.5	6.5	7.0	1.0	4.5	5.0	4.5	5.5	5.0	8.5	5.5	7.5	2.5	5.0
4.0	5.0	3.0	P8	5.5	7.0	4.5	4.5	4.5	7.5	5.5	5.5	5.5	7.0	5.0	5.5	5.5	6.5
4.5	6.5	2.5	7.5	4.5	5.0	3.5	2.5	2.5	3.5	4.5	4.5	3.5	5.5	3.5	8.5	5.0	3.5
8.5	8.0	3.0	10.0	8.0	P6	8.0	4.5	4.5	4.5	3.5	7.0	6.0	P	6.5	7.5	6.0	5.5
P	5.5	P	8.0	6.5	7.0	2.5	3.5	3.5	5.0	5.5	5.5	5.0	8.0	8.0	4.5	7.0	2.5
P	3.5	8.5	5.5	5.0	6.0	7.0	4.5	2.5	4.5	4.0	4.5	5.5	6.5	4.5	P6	10.0	2.0
P	6.5	6.5	8.0	6.5	P5	8.5	7.0	3.5	6.5	7.5	10.0	10.0	8.0	6.5	3.0	P14	2.5
P	2.5	5.5	5.0	4.0	6.0	5.0	5.0	2.0	3.5	5.0	4.5	5.0	5.5	3.0	3.0	P10	2.5

B

-9A,AND T53-L-11

Condition Level																	
	UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-12992		UH-1D #65-9772			UH-1D #65-9739		UH-1B #61-0713		
4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4/68	4/9/68	4/19/68	5/2/68	4/8/68	4/10/68	4/17/68	4/23/68	5/14/
6.5	4.0	9.5	P10	3.5	7.0	7.5	2.5	5.0	4.5	2.5	9.5	4.5	2.5	5.5	3.0	5.0	4.0
1.0	1.5	1.0	1.0	1.0	1.5	1.0	1.0	1.0	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5
2.5	4.0	3.5	5.5	3.0	6.0	4.0	8.0	2.5	3.5	3.5	5.5	7.5	3.5	6.5	2.5	2.5	3.0
4.0	P13	5.5	2.0	3.5	5.5	3.5	5.5	2.0	2.5	4.0	4.0	3.5	4.0	4.5	3.0	3.0	3.0
3.5	9.0	5.0	2.5	3.0	7.0	4.5	6.0	2.0	4.5	3.5	3.5	3.5	4.5	5.0	4.0	3.5	2.5
3.5	4.5	3.5	3.5	4.5	8.0	4.5	6.5	1.5	5.5	6.0	4.5	3.0	3.5	6.0	5.0	3.0	5.0
5.0	6.5	4.5	7.5	4.5	4.5	6.0	7.5	2.5	4.5	5.0	4.5	4.5	2.5	5.5	4.0	2.5	3.5
2.0	2.0	3.0	3.0	3.5	6.5	2.0	5.5	2.0	2.5	4.5	2.0	3.0	3.5	7.5	4.0	3.5	2.0
3.5	2.0	4.5	5.5	5.0	6.5	5.0	5.0	2.0	5.5	5.5	4.0	3.5	2.5	5.5	4.0	3.5	4.0
2.5	3.0	6.0	6.5	5.0	9.5	5.5	6.5	1.5	4.5	7.0	4.5	4.5	4.0	5.5	4.5	2.5	4.0
3.0	2.0	6.0	7.5	4.5	6.5	6.5	5.0	2.0	5.0	5.5	5.0	3.5	4.5	6.5	3.5	4.5	4.5
2.5	4.0	7.0	5.5	4.0	5.0	5.0	7.5	2.5	4.0	5.5	5.5	5.5	3.5	8.0	4.0	2.0	4.0
4.5	5.0	4.5	5.5	5.0	8.5	5.5	7.5	2.5	5.0	6.5	6.0	3.5	5.5	9.5	5.0	4.0	6.5
4.5	7.5	5.5	5.5	5.5	7.0	5.0	5.5	5.5	6.5	4.5	4.5	8.5	4.5	4.5	4.5	6.5	4.5
2.5	3.5	4.5	4.5	3.5	5.5	3.5	8.5	5.0	3.5	3.5	5.0	P5	4.5	5.0	2.0	3.0	5.5
4.5	4.5	3.5	7.0	6.0	P	6.5	7.5	6.0	5.5	4.5	5.5	8.0	3.5	6.5	4.5	5.5	9.0
3.5	5.0	5.5	5.5	5.0	8.0	8.0	4.5	7.0	2.5	4.5	3.5	5.5	3.5	5.5	5.5	7.0	6.0
2.5	4.5	4.0	4.5	5.5	6.5	4.5	P6	10.0	2.0	9.5	2.0	P6	5.5	3.0	4.0	2.0	3.0
3.5	6.5	7.5	10.0	10.0	8.0	6.5	3.0	P14	2.5	10.0	2.0	2.5	9.5	4.5	2.5	3.0	10.0
2.0	3.5	5.0	4.5	5.0	5.5	3.0	3.0	P10	2.5	8.0	1.5	2.5	5.5	2.5	1.5	1.5	7.0

C

em	Component		Mic Select	Lock Select	Ratio Set	Gain Set	Condition Limit	YUH-1D #60-6032			UH-1D #65-9773			UH-1D	
								1/18/68	2/14/68	5/6/68	1/17/68	1/22/68	2/15/68	2/6/68	2
2	Fuel Control Main Drive Gears		2	N1	.1352	5-25	Reject 8	8.5	6.5	4.0	1.0	3.5	2.5	8.0	
3	N1 Tachometer Drive Gears, ADGB		2	N1	.1640	5-25		9.5	4.5	5.0	2.0	2.5	2.5	6.0	
4	Spur Idler Gears, ADGB		2	N1	.1742	5-25		P8	3.5	10.0	1.5	2.5	2.0	5.5	
5	Fuel Control Drive Gears		2	N1	.1772	5-20		7.5	3.0	3.5	1.0	2.0	1.5	4.0	
6	Bevel Drive Gears, ADGB		2	N1	.3172	5-20		6.5	3.5	4.0	1.5	1.5	1.5	7.5	
7	No. 3 Main Brg	f_1	2	N2	.3241	5-20		9.0	3.5	7.5	1.0	2.5	8.0	8.5	
8		f_2	2	N2	.2451	5-20		6.5	4.5	6.5	1.0	2.5	7.0	P	
9		f_B'	2	N2	.2255	5-20		7.5	3.5	5.0	1.0	2.5	7.0	5.0	
0		$3f_B'$	2	N2	.7007	5-25		7.5	4.0	8.5	2.5	4.0	9.5	7.5	
1	No. 4 Main Brg	f_1	2	N2	.2206	5-20		6.0	3.0	5.5	1.0	2.0	1.0	3.0	
2		f_2	2	N2	.1444	5-20		7.0	3.0	5.0	1.0	4.5	6.5	5.0	
3		f_B'	2	N2	.1451	5-20		6.0	3.5	3.5	0.5	2.5	7.5	3.0	
4		$3f_B'$	2	N2	.4574	5-25		8.5	4.5	P10	1.5	3.5	10.0	P	
5	No. 4 Main Brg (Option)	f_1	2	N2	.2341	5-20		5.5	3.5	5.5	0.5	2.0	7.0	5.0	
6		f_2	2	N2	.1540	5-20		6.0	5.0	5.0	2.0	3.0	9.0	4.0	
7		$3f_B'$	2	N2	.4556	5-25		7.5	5.0	10.0	1.0	3.0	9.5	P	
8	Bevel Drive Gears, ADGB		2	N2	.1127	5-25		6.0	4.0	P10	1.5	5.5	5.5	6.0	
9			2	N2	.1167	5-25		4.0	3.5	4.0	1.0	5.0	4.5	3.0	
0	Spur Idler Gears, ADGB		2	N2	.1644	5-25		4.5	5.5	5.5	1.0	4.0	6.0	7.0	
1	Output Gears, Low Speed		2	N2	.3022	2-20		5.0	3.5	6.5	0.5	1.5	5.5	3.5	
2	Output Gears, High Speed		2	N2	.6141	5-20		6.0	3.5	5.5	1.5	2.0	6.5	6.5	

ms 1 through 17 and 27 through 37 refer to numbers in parentheses in Figure 11.
ms 18 through 26 refer to numbers in parentheses in Figure 7.
ms 38 through 42 refer to numbers in parentheses in Figure 8.

TABLE II. CONTINUED

Condition Level																		
) #65-9770		UH-1B #62-2101		UH-1B #61-0778					UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-12992	
/19/68	3/25/68	2/19/68	2/23/68	2/23/68	3/8/68	3/28/68	4/8/68	4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4/68
6.5	5.5	6.5	P7	P10	P10	6.5	4.5	5.5	7.5	8.0	5.0	5.0	P	6.5	8.0	6.5	5.0
5.0	6.5	3.0	7.5	7.5	P11	7.0	3.5	3.0	9.0	6.5	7.5	3.0	10.0	10.0	7.5	5.5	4.5
5.0	6.5	4.0	7.5	6.0	P6	7.5	7.0	3.0	9.5	7.5	4.5	10.0	10.0	10.0	9.5	8.5	6.5
3.5	5.0	4.5	4.5	4.5	6.5	3.0	5.5	2.5	7.5	4.5	3.5	5.0	5.5	6.5	5.0	4.0	2.5
2.0	5.5	3.0	6.0	5.5	7.0	4.5	4.5	4.5	5.5	5.0	4.5	3.0	8.5	9.5	6.0	4.5	4.5
2.5	5.5	3.0	5.5	4.5	8.5	5.0	4.5	5.0	5.5	4.5	5.5	9.5	6.5	6.5	6.0	5.0	6.5
4.0	4.0	3.0	6.5	3.0	9.5	6.5	5.5	4.5	6.5	4.5	6.5	10.0	4.5	5.5	8.5	5.5	5.5
2.5	5.5	3.0	5.5	3.0	4.0	5.0	5.5	4.5	4.5	4.0	5.5	5.0	4.5	6.0	3.5	6.0	4.5
5.5	8.0	3.0	8.5	6.5	9.5	P7	7.0	P5	6.5	5.0	5.5	5.5	10.0	8.5	6.5	6.0	8.5
3.0	5.5	2.0	4.5	5.5	6.5	4.0	5.5	4.0	5.0	5.5	3.5	7.5	8.0	7.0	5.5	5.0	6.5
5.5	6.0	P	P8	7.5	P8	6.5	5.5	8.5	6.0	5.0	5.5	4.0	9.5	7.5	3.0	4.5	5.5
3.5	4.0	4.5	6.5	4.0	7.5	5.0	4.0	4.5	5.5	3.5	3.5	4.5	5.5	5.0	4.0	4.5	4.5
4.0	7.5	2.5	7.5	7.5	9.5	9.5	4.5	8.5	8.5	7.5	8.5	8.5	P	P7	9.5	6.0	9.0
3.0	4.5	3.0	9.0	3.5	10.0	5.0	3.0	4.5	4.5	2.5	3.0	4.0	4.5	6.0	4.5	4.0	5.5
4.5	3.5	4.5	8.5	5.0	P8	8.5	2.5	5.0	5.5	8.5	4.5	6.5	6.5	6.5	4.5	4.5	5.0
3.5	P6	2.0	10.0	8.5	P6	7.0	4.5	10.0	8.5	7.5	7.5	6.5	P	P8	9.5	6.5	7.5
6.5	4.5	5.5	7.5	5.5	6.0	6.5	3.5	2.5	9.5	7.0	7.0	2.5	7.0	7.0	2.5	8.5	6.5
5.5	2.5	4.5	8.0	4.5	7.5	5.5	3.0	2.0	3.5	4.5	3.0	3.5	7.5	4.5	2.0	7.0	3.0
4.0	6.0	P	P10	6.5	9.5	9.0	4.5	5.0	4.5	5.5	4.5	7.5	9.5	7.5	8.0	6.5	P7
1.5	3.5	2.0	1.5	2.5	6.5	4.5	2.0	4.0	8.0	9.0	7.0	6.0	4.0	4.5	4.5	3.0	4.5
3.0	4.5	2.0	7.5	3.5	8.5	4.5	4.5	5.0	5.0	5.5	6.5	4.0	5.5	10.0	5.0	4.5	5.5

B

Condition Level																	
	UH-1B #65-9771				UH-1D #65-9959			UH-1D #63-12992		UH-1D #65-9772			UH-1D #65-9739		UH-1B #61-0713		
23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4/68	4/9/68	4/19/68	5/2/68	4/8/68	4/10/68	4/17/68	4/23/68	5/14/68
5.5	7.5	8.0	5.0	5.0	P	6.5	8.0	6.5	5.0	5.5	4.5	8.5	6.0	5.0	5.5	6.0	3.5
3.0	9.0	6.5	7.5	3.0	10.0	10.0	7.5	5.5	4.5	6.5	6.0	8.0	6.0	5.0	4.0	3.5	5.0
3.0	9.5	7.5	4.5	10.0	10.0	10.0	9.5	8.5	6.5	8.0	4.5	9.5	7.5	5.5	8.0	4.5	5.5
2.5	7.5	4.5	3.5	5.0	5.5	6.5	5.0	4.0	2.5	5.0	3.0	6.5	4.5	4.0	6.0	3.0	4.5
4.5	5.5	5.0	4.5	3.0	8.5	9.5	6.0	4.5	4.5	5.5	3.5	5.5	3.5	4.5	4.5	3.5	5.0
5.0	5.5	4.5	5.5	9.5	6.5	6.5	6.0	5.0	6.5	5.0	4.5	8.5	6.5	4.5	6.0	6.0	4.0
4.5	6.5	4.5	6.5	4.0	4.5	5.5	8.5	5.5	5.5	4.5	4.0	9.5	5.5	4.5	5.5	3.0	4.0
4.5	4.5	4.0	5.5	5.0	4.5	6.0	3.5	6.0	4.5	4.5	3.0	4.5	5.0	6.0	3.0	2.5	3.5
P5	6.5	5.0	5.5	5.5	10.0	8.5	6.5	6.0	8.5	6.5	8.0	8.0	4.5	6.5	8.0	6.0	8.0
4.0	5.0	5.5	3.5	7.5	8.0	7.0	5.5	5.0	6.5	4.5	3.5	4.5	3.5	5.0	3.5	3.5	4.5
8.5	6.0	5.0	5.5	4.0	9.5	7.5	3.0	4.5	6.5	5.0	3.0	3.5	5.0	5.0	P8	5.0	5.0
4.5	5.5	3.5	3.5	4.5	5.5	5.0	4.0	4.5	4.5	5.5	2.0	3.0	4.5	4.0	5.5	4.5	3.5
8.5	8.5	7.5	8.5	8.5	P	P7	9.5	6.0	9.0	9.0	6.5	9.5	7.5	2.5	6.0	4.5	9.0
4.5	4.5	2.5	3.0	4.0	4.5	6.0	4.5	4.0	5.5	5.0	5.5	5.0	5.5	3.0	3.5	3.5	3.0
5.0	5.5	8.5	4.5	6.5	6.5	6.5	4.5	4.5	5.0	3.0	2.5	5.5	4.5	3.0	3.5	3.0	2.5
0.0	8.5	7.5	7.5	6.5	P	P8	9.5	6.5	7.5	9.5	4.5	9.5	6.0	2.5	6.0	5.5	7.5
2.5	9.5	7.0	7.0	2.5	7.0	7.0	2.5	8.5	6.5	6.5	3.5	3.5	6.5	3.0	3.5	1.0	3.5
2.0	3.5	4.5	3.0	3.5	7.5	4.5	2.0	7.0	3.0	7.0	4.0	4.0	6.0	2.5	3.0	2.0	2.5
5.0	4.5	5.5	4.5	7.5	9.5	7.5	8.0	6.5	P7	6.5	5.0	8.5	4.5	2.5	8.0	4.0	3.5
4.0	8.0	9.0	7.0	[illegible]	4.0	4.5	4.5	3.0	4.5	3.5	3.0	5.0	2.5	2.5	3.5	2.5	2.0
5.0	5.0	5.5	6.5	[illegible]	5.5	10.0	5.0	4.5	5.5	7.0	4.0	5.5	6.5	4.5	5.5	3.5	6.0

TABLE III. AU

Item	Component		Mic Select	Lock Select	Ratio Set	Gain Set	Condition Limit	YUH-1D #60-6032 1/18/68	2/14/68	5/6/68	UH-1D #65-9773 1/17/68	1/22/68	2/15/68	2/6/6
	Start													
	Clear						Set rpm Meter							
	N1 Cal		Cal	N1	.3321	5-5	Set Max							
	N2 Cal		Cal	N2	.3533	5-5	Set Max							
	Mic 1 Normalize (Test Level-10)		1	N1	1.1223	5-25	Set 5							
	First-Stage Compressor (Lock Check)		1	N1	.7333	5-10	Peg							
1	Input Quill Double-Row Brg	f_1	1	N2	.0641	5-25	Reject 8	4.5	P5	3.0	P	P25	9.5	P11
2	↓	f_2	1	N2	.0441	2-25	↓	7.5	P9	4.0	P	P25	6.5	P10
3	↓	$3f_B'$	1	N2	.1366	2-25	↓	3.5	3.0	2.5	P	P14	4.5	6.0
4	Lower Transmission Offset Driven Spur Gear and Input Quill Brg	f_1	1	N2	.0331	5-15	↓	3.5	8.0	2.5	P	P17	P5	P8
5	↓	f_2	1	N2	.0212	5-15	↓	5.0	P7	3.5	P	P20	8.5	P5
6	↓	f_B'	1	N2	.0176	5-15	↓	4.5	8.5	10.0	P	P19	7.5	P17
7	↓	$3f_B'$	1	N2	.0573	2-25	↓	3.5	9.0	2.5	P	P20	7.5	P
8	Lower Transmission Output Quill Brg	f_1	1	N2	.0376	3 20	↓	3.5	8.0	3.0	P	P22	P8	P7
9	↓	f_2	1	N2	.0257	5-15	↓	5.5	7.5	3.0	P	P17	8.0	P5
10	↓	$3f_B'$	1	N2	.0744	2-25	↓	3.5	3.5	1.5	P	P15	4.5	9.5
11	Input Quill Journal Brg	f_1	1	N2	.0527	2-25	↓	P	P10	3.0	P	P21	7.5	P10
12	↓	f_2	1	N2	.0336	5-15	↓	3.0	6.5	3.5	P	P20	8.0	P5
13	↓	$3f_B'$	1	N2	.1161	2-25	↓	2.5	5.0	1.5	9.5	P15	3.5	5.0
	Mic 1 Normalize		1	N1	1.1223	5-25	Check 5							
14	Input Quill Journal Brg (Option)	f_1	1	N2	.0474	2-25	Reject 8	5.0	P10	3.5	P	P25	P10	P10
15	↓	f_2	1	N2	.0312	5-15	↓	6.5	6.5	9.5	P	P20	8.0	P5
16	↓	$3f_B'$	1	N2	.1147	2-25	↓	1.0	3.0	1.5	P	P15	4.0	4.0
17	Main Drive Driven Bevel Gear Double-Row Brg	f_2	1	N2	.0403	3-20	↓	3.0	P8	3.5	P	P22	P5	P8
18	↓	f_B'	1	N2	.0346	3-20	↓	3.0	6.5	3.5	P	P22	P5	P7
19	↓	$3f_B'$	1	N2	.1263	2-25	↓	2.0	3.0	1.5	9.5	P13	4.5	4.0
20	Main Driven Bevel Gear Double-Row Brg (Option)	f_B'	1	N2	.0323	5-15	↓	4.5	6.0	2.5	P	P18	9.5	P5
21	↓	$3f_B'$	1	N2	.1171	2-25	↓	1.5	3.0	2.0	9.5	P13	4.5	4.5
22	Main Driven Bevel Gear Single-Row Brg	f_2	1	N2	.0503	5-20	↓	3.5	P7	4.0	P	P24	9.0	P8
23	↓	$3f_B'$	1	N2	.1415	2-25	↓	1.5	2.5	1.5	P	P14	5.5	4.0
24	First-Stage Rotating Carrier Brg, High Speed	f_1	1	N2	.0264	5-15	↓	3.0	7.0	2.5	P	P18	8.5	9.0
25	Lower Transmission Offset Spur Gear Brg	f_1	1	N2	.1053	5-20	↓	2.5	3.5	3.5	P	P14	6.5	8.0
26	↓	f_2	1	N2	.0766	2-25	↓	4.0	4.5	1.5	P	P17	5.5	P9
27	↓	f_B'	1	N2	.0670	2-25	↓	2.0	5.5	2.0	P	P18	7.5	8.5
28	↓	$3f_B'$	1	N2	.2521	5-25	↓	1.5	5.5	3.0	P	P17	5.5	6.5

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TABLE III. AUTOMAT

Component		Mic Select	Lock Select	Ratio Set	Gain Set	Condition Limit	YUH-1D #60-6032 1/18/68	YUH-1D #60-6032 2/14/68	YUH-1D #60-6032 5/6/68	UH-1D #65-9773 1/17/68	UH-1D #65-9773 1/22/68	UH-1D #65-9773 2/15/68	UH-1D 2/6/68	UH-1D 2/1
Start														
Clear						Set rpm Meter								
N1 Cal		Cal	N1	.3321	5-5	Set Max								
N2 Cal		Cal	N2	.3533	5-5	Set Max								
Mic 1 Normalize (Test Level-10)		1	N1	1.1223	5-25	Set 5								
First-Stage Compressor (Lock Check)		1	N1	.7333	5-10	Peg								
Input Quill Double-Row Brg	f_1	1	N2	.0641	5-25	Reject 8	4.5	P5	3.0	P	P25	9.5	P11	P
	f_2	1	N2	.0441	2-25		7.5	P9	4.0	P	P25	6.5	P10	P
	$3f_B'$	1	N2	.1366	2-25		3.5	3.0	2.5	P	P14	4.5	6.0	9
Lower Transmission Offset Driven Spur Gear and Input Quill Brg	f_1	1	N2	.0331	5-15		3.5	8.0	2.5	P	P17	P5	P8	P
	f_2	1	N2	.0212	5-15		5.0	P7	3.5	P	P20	8.5	P5	P
	f_B'	1	N2	.0176	5-15		4.5	8.5	10.0	P	P19	7.5	P17	P
	$3f_B'$	1	N2	.0573	2-25		3.5	9.0	2.5	P	P20	7.5	P	P
Lower Transmission Output Quill Brg	f_1	1	N2	.0376	3-20		3.5	8.0	3.0	P	P22	P8	P7	P
	f_2	1	N2	.0257	5-15		5.5	7.5	3.0	P	P17	8.0	P5	P
	$3f_B'$	1	N2	.0744	2-25		3.5	3.5	1.5	P	P15	4.5	9.5	P
Input Quill Journal Brg	f_1	1	N2	.0527	2-25		P	P10	3.0	P	P21	7.5	P10	P
	f_2	1	N2	.0336	5-15		3.0	6.5	3.5	P	P20	8.0	P5	P
	$3f_B'$	1	N2	.1161	2-25		2.5	5.0	1.5	9.5	P15	3.5	5.0	P
Mic 1 Normalize		1	N1	1.1223	5-25	Check 5								
Input Quill Journal Brg (Option)	f_1	1	N2	.0474	2-25	Reject 8	5.0	P10	3.5	P	P25	P10	P10	P
	f_2	1	N2	.0312	5-15		6.5	6.5	9.5	P	P20	8.0	P5	P
	$3f_B'$	1	N2	.1147	2-25		1.0	3.0	1.5	P	P15	4.0	4.0	P
Main Drive Driven Bevel Gear Double-Row Brg	f_2	1	N2	.0403	3-20		3.0	P8	3.5	P	P22	P5	P8	P
	f_B'	1	N2	.0346	3-20		3.0	6.5	3.5	P	P22	P5	P7	P
	$3f_B'$	1	N2	.1263	2-25		2.0	3.0	1.5	9.5	P13	4.5	4.0	9.
Main Driven Bevel Gear Double-Row Brg (Option)	f_B'	1	N2	.0323	5-15		4.5	6.0	2.5	P	P18	9.5	P5	P1
	$3f_B'$	1	N2	.1171	2-25		1.5	3.0	2.0	9.5	P13	4.5	4.5	P1
Main Driven Bevel Gear Single-Row Brg	f_2	1	N2	.0503	5-20		3.5	P7	4.0	P	P24	9.0	P8	P1
	$3f_B'$	1	N2	.1415	2-25		1.5	2.5	1.5	P	P14	5.5	4.0	8.
First-Stage Rotating Carrier Brg, High Speed	f_1	1	N2	.0264	5-15		3.0	7.0	2.5	P	P18	8.5	9.0	P1
Lower Transmission Offset Spur Gear Brg	f_1	1	N2	.1053	5-20		2.5	3.5	3.5	P	P14	6.5	8.0	P1
	f_2	1	N2	.0766	2-25		4.0	4.5	1.5	P	P17	5.5	P9	P1
	f_B'	1	N2	.0670	2-25		2.0	5.5	2.0	P	P18	7.5	8.5	P1
	$3f_B'$	1	N2	.2521	5-25		1.5	5.5	3.0	P	P17	5.5	6.5	8.

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TOMATIC TAPE NO. 111 READINGS FOR SELECTED TRANSMISSION BEARINGS (REFER TO FIGURE 9)

									Condition Level								
UH-1D #65-9770			UH-1B #62-2101		UH-1B #61-0778					UH-1B #65-9771				UH-1D #65-9959			UH-1D #12992	
8	2/19/68	3/25/68	2/19/68	2/23/68	2/23/68	3/8/68	3/28/68	4/8/68	4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4
P16	6.0	P10	5.5	5.5	6.5	6.0	2.5	2.0	P8	P14	P9	2.5	P11	P11	2.5	10.0	2.
P20	7.0	7.0	7.5	6.5	7.5	7.5	2.0	3.0	P10	P12	P12	2.0	P12	P15	3.0	10.0	2.
9.5	3.5	6.5	4.0	3.0	3.5	3.5	2.0	2.5	3.5	5.5	5.0	.5	5.0	8.5	1.5	3.5	1.
P13	6.0	8.0	4.5	3.5	4.0	4.0	2.5	1.5	6.5	P7	9.0	2.5	P5	P9	3.0	6.5	1.
P15	6.5	5.5	3.5	3.5	4.0	4.0	1.0	1.0	P5	P9	6.5	2.5	P10	P11	4.5	7.5	2.
P17	8.5	P14	4.5	5.0	5.5	4.0	2.0	2.0	P9	P9	P10	3.5	P11	P12	P12	9.5	3.
P16	6.0	8.0	8.0	9.5	P19	P10	2.0	2.5	6.5	9.5	9.5	1.5	7.5	P10	3.0	9.5	1.
P16	P7	8.5	7.5	6.0	6.5	5.0	2.5	4.0	P7	P10	P9	3.0	P10	P13	3.5	8.5	2.
P14	P10	9.5	4.5	5.0	5.5	5.0	3.5	3.0	P11	P10	P11	4.0	10.0	P10	3.5	6.0	5.
P12	4.5	P5	3.5	3.5	4.5	5.5	2.0	4.0	4.5	6.5	6.5	1.0	7.0	8.5	1.5	4.5	1.
P10	P7	2.5	4.0	6.0	6.0	8.0	2.5	3.5	P10	P15	9.5	2.0	P7	P12	4.0	P25	P1
P15	6.0	8.5	6.0	4.5	5.0	4.5	1.0	2.5	7.5	P6	P6	2.5	10.0	P8	2.0	6.0	2.
P11	5.5	P10	6.0	3.0	P10	4.5	1.0	1.5	3.0	5.0	4.0	1.0	5.0	6.5	1.0	3.5	1.
P15	6.5	10.0	P15	P16	P21	P15	1.5	5.0	P9	P12	P11	3.0	P12	P14	3.0	P11	2.
P12	7.0	9.0	4.5	4.0	5.0	5.0	1.5	2.5	9.5	P5	P6	3.0	10.0	P9	P10	6.0	2.
P13	3.0	P10	3.5	2.0	3.5	3.0	1.5	1.5	4.5	4.0	4.5	1.5	6.5	8.5	1.5	4.0	1.
P15	9.0	7.0	4.5	5.0	6.5	4.0	2.0	3.0	P8	P5	P8	3.5	P10	P12	3.0	8.0	2.
P15	7.5	P10	6.5	4.5	5.5	7.0	1.5	2.5	P9	P10	P9	3.5	P10	P10	3.0	7.5	2.
9.5	3.0	7.0	3.5	4.5	6.5	4.5	1.5	3.0	3.5	4.5	4.5	1.5	5.0	6.0	1.0	3.5	1.
P12	7.0	5.5	3.5	4.5	3.5	4.0	1.5	1.5	9.0	9.0	8.5	3.5	7.5	P10	3.5	5.5	2.
P10	3.5	8.0	3.0	6.5	7.5	5.0	1.0	1.0	3.5	4.5	3.5	1.5	5.0	7.5	1.5	5.0	1.
P14	7.0	9.5	5.5	P10	P5	P20	2.5	P14	P8	P9	9.5	2.5	P10	P10	3.5	P10	2.
8.5	3.0	7.5	2.5	2.0	2.5	2.5	1.5	1.5	4.0	4.5	3.5	1.5	4.0	6.5	1.5	4.0	1.
P12	7.0	7.5	4.0	7.5	4.5	4.5	4.5	2.0	9.5	P5	10.0	2.5	P7	P9	3.0	P5	2.
P10	4.5	P15	6.5	3.5	P6	8.0	3.5	6.5	7.5	P7	9.5	2.0	7.5	9.5	2.5	4.0	1.
P10	3.5	10.0	3.0	4.0	4.5	3.5	1.5	4.0	6.5	7.5	P11	1.5	8.5	10.0	2.5	4.5	2.
P12	4.5	10.0	3.5	4.5	5.5	6.5	1.5	2.0	7.0	P6	P12	2.0	6.5	9.5	2.5	9.0	1.
8.5	4.5	10.0	3.0	2.5	5.0	2.5	1.5	2.0	6.0	7.5	6.5	3.0	7.5	10.0	2.0	4.0	1.

B

:FER TO FIGURE 9)

Condition Level																	
	UH-1B #65-9771				UH-1D #65-9959			UH-1D #12992		UH-1D #65-9772			UH-1D #65-9739		UH-1B #61-0713		
4/23/68	3/11/68	3/15/68	3/19/68	3/22/68	2/28/68	4/2/68	5/2/68	3/19/68	4/4/68	4/9/68	4/19/68	5/2/68	4/8/68	4/10/68	4/17/68	4/23/68	5/14/68
2.0	P8	P14	P9	2.5	P11	P11	2.5	10.0	2.0	5.5	5.0	5.5	3.5	5.0	2.0	2.5	4.5
3.0	P10	P12	P12	2.0	P12	P15	3.0	10.0	2.0	6.5	7.5	8.5	4.0	6.5	2.0	2.5	4.5
2.5	3.5	5.5	5.0	.5	5.0	8.5	1.5	3.5	1.5	3.0	2.0	3.0	2.5	2.5	2.0	1.5	2.5
1.5	6.5	P7	9.0	2.5	P5	P9	3.0	6.5	1.5	4.0	5.5	5.5	4.5	4.5	2.0	2.0	2.0
1.0	P5	P9	6.5	2.5	P10	P11	4.5	7.5	2.5	5.0	5.5	7.5	5.5	6.0	3.5	3.5	2.5
2.0	P9	P9	P10	3.5	P11	P12	P12	9.5	3.0	6.0	6.0	P12	5.0	8.0	4.5	4.5	8.5
2.5	6.5	9.5	9.5	1.5	7.5	P10	3.0	9.5	1.5	5.5	5.0	5.5	2.5	4.0	3.0	3.5	5.0
4.0	P7	P10	P9	3.0	P10	P13	3.5	8.5	2.0	6.5	5.5	5.5	3.5	4.5	4.5	3.0	3.5
3.0	P11	P10	P11	4.0	10.0	P10	3.5	6.0	5.5	9.5	P13	P10	4.0	5.5	4.0	3.0	3.5
4.0	4.5	6.5	6.5	1.0	7.0	8.5	1.5	4.5	1.0	3.5	3.0	2.5	2.0	2.5	P15	P12	P12
3.5	P10	P15	9.5	2.0	P7	P12	4.0	P25	P15	8.5	P10	P10	2.5	5.5	3.0	1.5	2.5
2.5	7.5	P6	P6	2.5	10.0	P8	2.0	6.0	2.0	4.5	5.0	5.0	3.5	4.0	2.0	2.5	2.5
1.5	3.0	5.0	4.0	1.0	5.0	6.5	1.0	3.5	1.0	2.0	2.0	2.5	1.0	2.5	1.5	2.0	1.5
5.0	P9	P12	P11	3.0	P12	P14	3.0	P11	2.5	5.5	4.5	3.0	3.5	6.0	4.0	3.0	4.5
2.5	9.5	P5	P6	3.0	10.0	P9	P10	6.0	2.0	5.0	4.5	P6	5.0	3.5	2.5	2.0	5.0
1.5	4.5	4.0	4.5	1.5	6.5	8.5	1.5	4.0	1.0	2.0	2.0	1.0	1.0	2.0	1.5	2.0	3.0
3.0	P8	P5	P8	3.5	P10	P12	3.0	8.0	2.0	5.5	5.5	4.0	4.0	3.5	5.0	3.0	4.0
2.5	P9	P10	P9	3.5	P10	P10	3.0	7.5	2.0	5.5	6.0	4.0	3.5	4.5	3.0	2.5	4.5
3.0	3.5	4.5	4.5	1.5	5.0	6.0	1.0	3.5	1.0	2.5	1.5	1.5	1.5	2.0	1.5	1.5	1.5
1.5	9.0	9.0	8.5	3.5	7.5	P10	3.5	5.5	2.0	5.0	5.0	3.0	3.5	4.5	5.0	2.0	2.0
1.0	3.5	4.5	3.5	1.5	5.0	7.5	1.5	5.0	1.5	2.0	1.5	1.5	1.5	2.5	2.0	2.0	2.0
P14	P8	P9	9.5	2.5	P10	P10	3.5	P10	2.5	5.5	5.5	3.0	4.0	5.5	P10	P5	10.0
1.5	4.0	4.5	3.5	1.5	4.0	6.5	1.5	4.0	1.0	2.5	2.0	2.0	1.5	1.5	1.5	1.0	1.5
2.0	9.5	P5	10.0	2.5	P7	P9	3.0	P5	2.5	7.0	P10	3.5	4.0	4.5	4.5	2.5	2.5
6.5	7.5	P7	9.5	2.0	7.5	9.5	2.5	4.0	1.0	4.0	3.0	3.0	2.0	3.5	P6	8.5	3.0
4.0	6.5	7.5	P11	1.5	8.5	10.0	2.5	4.5	2.0	3.0	2.5	1.5	1.5	2.0	2.0	1.5	2.5
2.0	7.0	P6	P12	2.0	6.5	9.5	2.5	9.0	1.0	2.5	2.5	1.5	2.5	3.5	2.0	1.0	2.0
2.0	6.0	7.5	6.5	3.0	7.5	10.0	2.0	4.0	1.0	3.5	2.0	2.0	4.0	4.5	1.5	1.5	5.5

CONCLUSIONS

It is concluded that:

1. Generally, the correlation between discrepancies detected by the CWEA-4 Sonic Analyzer and discrepancies visually detected is very good.

2. The use of the CWEA-4 Sonic Analyzer in conjunction with the UH-1 helicopter shows great potential as a successful indicator of power train component anomalies.

RECOMMENDATIONS

It is recommended that:

1. Since a limited number of malfunctions occurred with the analyzer during this program, a follow-on in-house program be initiated using known discrepant gears and bearings.

2. A study be made to determine to what extent analysis should be made at the operational level and at the depot level.

APPENDIX
SAMPLE CALCULATIONS

The following sample calculations are based on data from engine models T53-L-9, T53-L-9A, and T53-L-11:

1. Compressor

Example: 1st stage = 26 blades, N1 = 15,088 rpm

a. Fundamental rotational frequency

$$f_R = \frac{\text{Speed of compressor rotor, N1 (rpm)}}{60} = \frac{15,088}{60} = 251.5 \text{ cps}$$

b. Compressor rotor blade passage frequency

$C_1 = f_R \times$ no. of rotor blades $= 251.5 \times 26 = 6539$ cps

2. Accessory Drive Gearbox - Gas Producer Driven

Example: Inner drive spur gear (4b), N1 = 15,088 rpm, gear (1) = 34 teeth, gear (2) = 63 teeth, gear (3) = 21 teeth, gear (4a) = 40 teeth, and gear (4b) = 24 teeth (refer to Figure 7 for location of these gears)

a. RPM of gear

$$N_{gear(4b)} = N1 \times \frac{\text{No. of teeth on drive gear (1)}}{\text{No. of teeth on driven gear (2)}} \times \frac{\text{No. of teeth on drive gear (3)}}{\text{No. of teeth on driven gear (4a)}}$$

$$= 15,088 \times \frac{34}{63} \times \frac{21}{40} = 4274.9 \text{ rpm}$$

b. Rotational frequency

$$f_{gear(4b)} = \frac{\text{rpm of gear}}{60} \times \text{no. of gear teeth} = \frac{4274.9}{60} \times 24$$

$$= 1710 \text{ cps}$$

3. Bearing Formulas

Example: No. 1 main engine bearing, N1 = 15,088 rpm, d_B = 0.5000 in., d_1 = 2.2720 in., d_2 = 3.2720 in., and m = 13

a. Fundamental rotational frequency

$$f_R = \frac{\text{rpm of shaft}}{60} = \frac{15,088}{60} = 251.5 \text{ cps}$$

b. Frequency caused by irregularity on inner race

$$f_1 = f_R \, m \, \frac{d_2}{d_1 + d_2}$$

$$= 251.5 \times 13 \times \frac{3.2720}{2.2720 + 3.2720} = 1929.6 \text{ cps}$$

c. Frequency caused by irregularity on outer race

$$f_2 = f_R \, m \, \frac{d_1}{d_1 + d_2}$$

$$= 251.5 \times 13 \times \frac{2.2720}{2.2720 + 3.2720} = 1339.9 \text{ cps}$$

d. Frequency caused by spin of rolling element

$$f_B = f_R \, \frac{d_2}{d_B} \, \frac{d_1}{d_1 + d_2}$$

$$= 251.5 \times \frac{3.2720}{0.5000} \times \frac{2.2720}{2.2720 + 3.2720} = 674.5 \text{ cps}$$

e. Frequency caused by rough spot on rolling element

$$f_B' = 2f_B = 2 \times 674.5 = 1349.0 \text{ cps}$$

f. Frequency due to rotation of train of rolling elements

$$f_T = \frac{f_2}{m} = \frac{1339.9}{13} = 103.1 \text{ cps}$$

4. Ratios

Example: Component frequency = 7504 cps
Tracking frequency = 6525 cps

a. Decimal Ratio

$$\text{Decimal ratio} = \frac{\text{component frequency}}{\text{tracking frequency}} = \frac{7504}{6525} = 1.15003$$

b. Octal Ratio

Convert the decimal ratio to an octal ratio as follows:

(1) The number to the left of the decimal ratio is the first number of the octal number.

(2) Multiply all digits to the right of the decimal point in the decimal ratio by 8. The number to the left of the decimal point in this product is the first number to the right of the decimal point in the octal number.

(3) Multiply all digits to the right of the decimal point in the product obtained in (2) by 8. The number to the left of the decimal point in this product is the second number to the right of the decimal point in the octal number.

(4) Continue this process until the desired number of decimal places for the octal ratio is obtained.

(5) Round off the last decimal place using the number 4 as the mid-point since these numbers are to base 8.

Example: Decimal ratio = 1.15003

Multiply $0.15003 \times 8 = 1.20024$

$0.20024 \times 8 = 1.60192$

$0.60192 \times 8 = 4.81536$

$0.81536 \times 8 = 6.52288$

$0.52288 \times 8 = 4.18304$

Therefore, the octal ratio = 1.1146 rounded off to 4 decimal places. If the octal number had been 1.11475, the number rounded off to 4 decimal places would be 1.1150.

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13. ABSTRACT

This report covers work performed during a US Army Aviation Materiel Laboratories (USAAVLABS) in-house program to conduct a field application of the UH-1 series helicopter to evaluate the sonic analyzer and to verify the component-level limits determined by Curtiss-Wright Corporation under a previous Government contract.

The test program consisted of taking 33 runs on 11 UH-1 series helicopters. Real time analyses, along with analyses from magnetic tape recordings, were performed.

The CWEA-4 Sonic Analyzer shows good potential as a successful indicator of power train component anomalies for the UH-1 series helicopters based on the satisfactory performance and operational characteristics exhibited during the field application program.

Test results indicate that the following work must be done before the sonic analyzer can become operational:

1. Take readings with known malfunctions to determine the signature of a discrepant component.
2. Determine to what extent the analysis will be made at the operational level and at the depot level.
3. Make minor modifications on the analyzer.

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